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China Report

SCIENCE AND TECHNOLOGY

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CHINA REPORT
SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

TAPPING POTENTIAL OF THOSE RETURNED FROM STUDY ABROAD

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 12 Nov 85 pp 28-29

[Article by Li Tianhou [2621 1131 0624] and He Zhuo [0149 0587] of the Shenyang City CPC Committee Scientific Education Department: "Exploit the Potential of Talented People Who Have Gone Abroad for Study and Training, Develop and Import Intellectual Resources"]

[Text] According to an investigation of 22 institutions of higher education and 14 scientific research and design units in the Shenyang scientific education system, 54.5 percent of the 321 personnel who have gone abroad for study and training for a year or more were sent after the 3d Plenum of the 11th CPC Central Committee. Of this group, our survey focused on questions related to the work, study, life and implementation of related policies for 116 persons and sought out their opinions in a comprehensive way. Advanced S&T personnel accounted for 26 persons or 22.4 percent of these 116 study and training personnel, middle level S&T personnel for 80 persons or 69.0 percent and elementary level S&T personnel for 10 persons or 8.6 percent.

I. The Latent Function of Importing Intellectual Resources

Of the 116 personnel surveyed, 40 persons or 34.5 percent went to Japan for study or training, 46 persons or 39.7 percent to the U.S., 8 persons or 6.9 percent to Switzerland, 7 persons or 6.0 percent to West Germany and 13 persons or 12.9 percent to other countries. The results of the survey show that sending out talented people and bringing in intellect rapidly improved the intellectual levels of S&T personnel and brought them very quickly into the forefront of world science and technology. This sort of importation of intellectual resources not only saves time and provides quick results but also conserves on intellectual investments. Imports of technology generally are not the most advanced but the importation of intellectual resources can lead to continual creation of advanced technologies.

In terms of scholarly and professional levels, 10 of the 116 personnel who returned from study and training abroad ["returned personnel" hereafter] obtained doctoral degrees. Some of them even were lauded as "post-doctorates" abroad and some were invited to be "visiting professors." They have become valuable intellectual wealth for the nation after completing their studies

and returning to China, and 40 percent of them are playing important roles. Six of the 116 returned personnel were approved as advisors for graduate students and 81 were advisors for masters graduate students, a total of about 75 percent. There were 35 persons responsible for important scientific research topics and most of the others undertook important educational and scientific research tasks and made definite achievements. There were 20 projects that obtained scientific research achievements awards at the provincial level and above, including six topics that reached advanced levels within China and four topics that reached advanced international levels.

The results of the survey show that the returned personnel are a formidable scientific and technical "shock brigade" that plays a leading role in educational and scientific research work. They have shown the precious value of importing intellectual resources and will be of inestimable utility in the strategic task of completing the "quadrupling" [of the total value of industrial and agricultural output by the year 2000].

II. Full Use of the Potential of Talented People Who Have Studied and Been Trained Abroad and Returned to China Remains To Be Achieved

It can be seen from the survey that although the returned personnel have revealed their latent functions, they have not been fully used. Only about 40 percent of them are playing a rather good role. It was learned from a survey of the stand taken by the personnel that only 4 of them or 3.4 percent feel happy about their work, study and living while 90 percent feel that although the efforts of the CPC Central Committee and CPC committees at all levels have made quite a bit of progress in work related to implementation of policies concerning intellectuals, they are not satisfactory. The main reasons include the following aspects:

1. A lack of a true understanding concerning the role of returned personnel

Some leaders understand the implementation of the policies simply as arranging for employment for returned personnel. There is a lack of serious research concerning the positions that returned personnel should be given before they can play their roles. Of the 116 returned personnel, 35 were placed in leadership positions at middle levels and above. Administrative work occupies 70 to 80 percent of their effort and time, which greatly weakens their scientific research and educational work. Some units have serious seniority problems. Those under 50 accounted for 80 percent of the returned personnel and 78 percent have middle or elementary level technical positions. The fact that they have "little seniority and are young" means that their professions are not put to use. There are no guarantees for manpower, materials or finances. They studies many things while abroad but cannot develop their work after returning to China, which is an enormous waste.

2. The existence of a "Leftist" bias toward intellectuals

Of the 116 people surveyed, 40 felt that the question of discrimination still exists. Just as Comrade Hu Yaobang pointed out in his report to the 12th CPC

Central Committee, "an erroneous viewpoint of neglecting education, science and culture and discrimination against intellectuals has been rather common in our party for a fairly long time." Some units are uneasy about the politics of returned personnel and feel that it is inevitable that they were subjected to several bad influences when abroad or at least that they are a political blank. This has stifled the ideas of returned personnel.

3. Irrational arrangements and utilization

The survey showed that the inability of returned personnel to integrate study and application is even more serious than for talented people trained in China. Of the 116 people surveyed, 23 persons or about 20 percent could not use the specializations and knowledge they had studied. A design academy engineer trained in Japan is an example. He specialized in research on basic theories of earthquake prevention in tall structures and is a valuable talented person in China's construction industry at the present time. After returning to China, however, it was arranged for him to take part in educational work at the Electronics University. This phenomenon of irrational utilization has led to serious losses in science and education activities and in scientific research and teaching, and it has made the returned personnel anxious.

4. Poor working conditions, backward scientific research measures, shortages of equipment and capital, inadequate matchups of personnel

Of the 116 people surveyed, 20 or about 17.2 percent wish to have time guarantees while 27 or 23.3 percent requested administrative expenditures. There were 31 people or 26.7 percent who wished to be matched up with assistants and 26 or 22.4 percent who had asked for additional equipment. Some 18 persons or 15.5 percent needed laboratories. The problems mentioned above were acutely apparent in the survey. An engineer at the Shenyang Casting Research Institute made major breakthroughs in Japan while engaged in research on iron-silicon system materials. There was no way to gather the 40,000 yuan in administrative expenses needed after returning to China so the work stopped. Many returned personnel said emotionally: "while abroad, we worked every second to do scientific research but we are helpless after returning to China."

5. A lack of support for scholarly activities

The returned personnel used their outstanding scholarly achievements to gain respect in foreign academic circles and to establish scholarly exchanges. All of the returned personnel wished to create the conditions to maintain foreign scholarly relationships and to make full use of this favorable conditions. Comments they added to the survey said that "science is flying ahead at present and knowledge is being renewed at an accelerated pace. We should be given the opportunity for frequent academic exchanges with foreign countries. Otherwise, we will "die" academically." However, most people lost the opportunity for relationships with foreign countries after returning to China.

6. Low wages, housing shortages, worries of trouble at home

Only 24 people or 20 percent of the 116 surveyed had [monthly] wages greater than 100 yuan while 80 percent received less than 100 yuan and 53 or about 45 percent of them less than 80 yuan. Ten of the returned personnel received doctoral degrees. Six of them are earning 78 yuan and have become known as "78 yuan doctors." One teacher who received a doctorate in Japan is engaged in research in the area of cardiovascular pharmacology but receives a wage of only 69 yuan at present. They said "we receive only a few bonuses and slightly higher wages, but our poor base and many debts mean that we still are difficult [poor] households."

The returned personnel have small houses. Some 92 percent of the 116 people surveyed were over 36 years of age and most of them have older people as well as children at home. Some 40 of them or 34.5 percent have no home or only a single room; 60 people or 51.7 percent lived in two rooms. Only 16 people or 13.8 percent lived in three rooms.

In addition, they also urgently demand a solution to the problem of knowledge renewal. Their professional and technical titles also were evaluated irrationally. Some prominent talented people with substantial scholarly achievements in the forefront of science recieved no increase in title, which has affected academic exchanges within China and with foreign countries and influenced their support of graduate students to train talented people. This has damaged the initiative of some of the returned personnel.

It can be seen from the results of the survey that many factors have affected the initiative of returned personnel. The largest and most apparent problem, however, concerns how to create working conditions for them, allow them to play their role to the fullest, make it possible for them to contribute the knowledge, intellect and capabilities that they have studied to the cause of socialist modernization and construction to the greatest degree, and make their greatest efforts to make the nation and the nationality wealthy and strong.

III. Opinions Concerning the Development and Importation of Intellectual Resources

We offer the following opinions concerning ways to make fullest use of the role of returned personnel and greatest use of imported intellectual resources:

1. Further implement policies concerning intellectuals. Leaders at all levels should have a profound understanding of the important role of talented people, who have returned to China from study and training abroad in the four modernizations drive. We must have full trust in them politically and allow them to have positions, responsibilities and rights in technical posts. In work, we should be active in creating the conditions for them and be conscientious in solving real problems for them so that they truly can play their roles.

2. Personnel whose specialization of study during their period abroad is not appropriate for the work they are engaged in after returning to China or who do not have substantial relationships should be permitted to move to units suited to their specializations and where they can play their roles fully. They should not be held back by the unit they are in for any pretext.

3. We propose that related departments establish scientific and technical experimentation and research funds for returned personnel, that they raise scientific research funds and that they have a certain amount of foreign exchange funds. The administrative expenditures needed for all scientific research projects set up by returned personnel and those with economic value can be allocated directly by the funding committee, with persons responsible for the projects controlling their utilization and financial departments serving only to investigate and supervise financial and economic discipline.

4. Adopt earnest measures for active creation and improvement of working conditions. Capital should be gathered from many places and we should be willing to spend money to purchase some advanced instruments and equipment. Make full use of and transform existing equipment. Actively develop cooperative activities for utilization of large scale sophisticated instruments and equipment in severe shortage. Encourage individuals to establish linkages with foreign countries to purchase instruments and equipment. Develop individual friendship relationships and make full use of any instruments, equipment and experimental materials that are available from foreign friends.

5. Academic echelons, scientific research groups and the appropriate assistants should be established for returned personnel who have rather high scholarly level and are engaged in research on major scientific topics. Their opinions concerning the composition of the personnel should be respected fully and we should not make rigid organizatinal arrangements.

6. Strive to release returned personnel from the tedious formalities of administrative activities. Those returned personnel with rather profound academic achievements, those who are responsible for important scientific research and educational tasks and those who really are not suited to administrative and managerial work generally should not be placed in administrative leadership positions. Returned personnel who already have been promoted to leadership positions also should strive to reduce as much as possible their administrative tasks to allow them to concentrate their efforts on doing good professional management work.

7. Improve and strengthen logistical work. Logistical personnel should establish an ideology of service to educational, scientific research and technical work, work conscientiously to serve scientific research and education work, and guarantee smooth progress in scientific research and educational work.

8. Have a full understanding of the value of knowledge, allow the labor of returned personnel to receive the compensation it should and improve their treatment in life.

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CSO: 4008/2043

NATIONAL DEVELOPMENTS

FANG YI ADDRESSES CAS CONFERENCE

OW020259 Beijing XINHUA Domestic Service in Chinese 1304 GMT 1 Feb 86

[By reporters Zhu Weixin, Zhang Jimin]

[Excerpts] Beijing, 1 February (XINHUA)--Twenty-two advanced collectives and 19 advanced workers who have distinguished themselves in scientific research, as well as 162 research groups that have achieved remarkable successes tackling key research problems during the Sixth 5-Year Plan were commended and warmly congratulated by Comrade Fang Yi at the opening ceremony of a work conference of the Chinese Academy of Sciences [CAS] today.

Addressing the meeting's opening ceremony, which took place at the Great Hall of the People, Comrade Fang Yi said that the CAS achieved fruitful results in serving economic construction and in ensuring steady development of basic research during the Sixth 5-Year Plan. He urged CAS comrades to continue to work hard in 1986, throw themselves into the great Seventh 5-Year Plan with even greater enthusiasm, and strive to achieve new successes for the CAS.

He pointed out: Being an important force in the nation's scientific and technological sphere, the CAS has the resources of organizing various branches of learning in conducting comprehensive research. The CAS should now shoulder even more important projects than during any other period in the past. It should be determined to accomplish some major projects with important bearing on the national economy and people's livelihood, qualitatively accomplish key state research projects, and make new contributions to the national eocnomic growth and scientific and technological progress.

Comrade Fang Yi stressed: It has been proven by ample facts that cooperation yields better efficiency, speed, and results. The CAS should freely establish all forms of cooperation with various industrial departments, institutes of higher learning, local authorities, and large and medium-sized enterprises. He said: The proposal jointly presented by a number of scientists at this meeting to strengthen the CAS's ties with large enterprises is a good one because it can further liberate productivity by removing regional and departmental restrictions.

Yan Jici, vice chairman of the NPC Standing Committee, and leading members of departments concerned were present at today's meeting.

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CSO: 4008/2059

NATIONAL DEVELOPMENTS

CHINESE ACADEMY OF SCIENCES ON SCHEDULE WITH PROJECTS

OW031602 Beijing XINHUA in English 1453 GMT 3 Feb 86

[Text] Beijing, 3 Feb (XINHUA)--Construction of several large scientific devices are proceeding on schedule at the Chinese Academy of Sciences [CAS].

An electron-positron collider, a research facility for heavy ion research, and a 2.16-meter-in-diameter astronomical telescope are three of the major projects being built by the academy which will be completed during the Seventh Five-Year Plan (1986-1990).

Work on the collider at the High Energy Physics Institute in Beijing began in October 1984 and will be finished in 1988. The electron-positron collider consists of five major parts: a linear accelerator 200 meters in length, a 240-meter-in-perimeter storage ring, a 400-ton detector, a synchrotron radiation laboratory and a computer center.

So far the tunnel for the linear accelerator and the building for the klystron, which is a devise consisting of ultra-high frequency electron tubes which vary the velocities of a stream of electrons, have been completed, according to an announcement made by the academy's planning bureau here today.

Chinese scientists have developed a prototype of the linear accelerator and other key equipment, including radio frequency oscillators, dipole bending and quadropole focusing magnets and klystrons.

Completion of the collider will promote China's research in high energy physics and study of synchrotron radiation, which deals with the origin of cosmic radio waves.

China's largest heavy ion research facility is being built at the Lanzhou Institute of Modern Physics in Gansu Province. The facility includes a sector focusing cyclotron, a 60-meter-long transport line, a sector separating cyclotron and an eight-terminal laboratory.

Construction of the facility started in 1978 and will be completed in 1988. The sector magnets are now being installed.

The facility will be used for basic research on middle- and low-energy heavy ion nuclear reactions, as well as atomic physics and material science.

The 2.16-meter-in-diameter telescope being produced by the Nanjing Astronomical Instrument Plant will be the country's largest. It will be installed at Hebei Province's Xinglong Observatory, attached to the Beijing Observatory. At present, China's largest astronomical telescope is 1.26 meters in diameter. Installation work for the new telescope is expected to be completed in 1988.

An official of the Academy's Planning Bureau told XINHUA that in the next five years, the Academy will complete a number of pilot projects on robots, bio-engineering and new chemical materials, a synchronous radiation laboratory at China's University of Science and Technology, a scientific data bank and information system, a millimeter-wave radio astronomical telescope in Qinghai province, and experimental biology and earth sciences stations.

He said the completion of these will promote China's basic research as well as national economic development.

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CSO: 4010/1029

NATIONAL DEVELOPMENTS

3,000 ADVANCED TECHNOLOGY IMPORTS PLANNED FOR 1986-88

Shanghai JIEFANG RIBAO in Chinese 27 Nov 85 p 1

[Article by Huang Huachu [7806 5478 0443]: "More Technology Imports Planned for 1986-88"]

[Text] The State Economic Commission has decided that in addition to the 3,000 pieces of technology imported from abroad during the past 3 years, China will import a similar number of pieces of advanced technology in the first 3 years of the Seventh 5-Year Plan to promote the technological modernization of Chinese industry.

Most of the several thousand pieces of technology and equipment imported in the last 3 years of the Sixth 5-Year Plan reached international standards of the 1970's and early 80's. They have broadened our technological thinking and vision, raised the technological level of industry, and enhanced our capacity for self-reliance. The next 3,000 pieces of technology to be imported will be more geared toward the major thrusts in our industrialization, based on the present circumstances and needs of our enterprises. They will include know-how and key installations to complement or help assimilate what we have imported in the last 3 years. They will be the technology for making some of the products in short supply, particularly basic parts and components. They will be technology which can help light, textile, and electrical machinery industries upgrade and modernize their products and earn more foreign exchange. They will be the technology of quality control, standards testing, and so on.

The State Economic Commission has demanded that extra caution be exercised in determining our imports, that centralized import planning be carried out, and that foreign exchange be tapped in a multitude of avenues. In addition, scientific research, design, standards, and patent departments must strengthen feasibility research.

12581
CSO: 4006/532

NATIONAL DEVELOPMENTS

LU DONG ON IMPORTATION OF ADVANCED TECHNOLOGY

OW161228 Beijing XINHUA in English 1152 GMT 16 Jan 86

[Text] Beijing, 16 Jan (XINHUA)--A senior economic official today urged China's electronics industry to continue importing advanced technology from abroad and upgrading existing large- and medium-sized enterprises to produce more and better electronic goods.

Lu Dong, minister in charge of the State Economic Commission, told national and local officials attending an ongoing conference on the electronics industry here that imported technologies should be absorbed before efforts are made to develop China's own.

At the same time, he said, "considering its potentially important role in China's modernization drive, the electronics industry should maintain a faster speed of development."

Over the past five years, China's electronics industry has imported over 1,000 items of technology. One-third of the country's major electronics factories have been at least partially renovated. The annual growth rate of the industrial output value averaged 22.8 percent.

Lu said more attention should be paid to production of electronic computers, massive integrated circuits and other key products to bring them into mass production.

Between 1981 and 1985, China's electronics enterprises produced 1,500 mainframe computers, 65,000 microcomputers, 150 million integrated circuits, 35 billion electronic components, and 1.32 million meters and instruments.

Production of electronic consumer goods increased sharply, compared to the 1976-1980 period. Manufacturing of tape recorders, for example, jumped 22 times to 25 million and televisions seven times to 40 million.

To improve quality, Lu said, production of major electronic goods should aim at world standards. He suggested that by 1990 many should be at the advanced world level.

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CSO: 4010/1029

NATIONAL DEVELOPMENTS

BENEFITS OF IMPORTING TECHNOLOGY DISCUSSED

Beijing ZHONGGUO KEJI LUNTAN [FORUM OF SCIENCE AND TECHNOLOGY IN CHINA] No 1, Sep 85 pp 42-44

[Article by Li Baoheng [2621 1405 1854]: "A Shortcut to Accelerating Our Technical Progress"]

[Text] To realize the strategic goals of our socialist modernization, we must rely upon advances in technology. If we do not base ourselves upon advances in technology, we cannot develop our production forces and become modernized.

So how can we accelerate our technical progress?

Importing technology is the road all developing countries must follow to accelerate technical progress. China, too, must self-consciously take this shortcut.

To import technology we must have an open-door policy, and must open up both internally and to the outside. Since our coastal cities have been opened, there have been remarkable advances in the importation of technology, especially over the last 2 years. Importation projects have grown abruptly, which has quickened the pace of the technical transformation of enterprises, has improved product quality, has increased the kinds of products, has raised the level of labor productivity and operational management, and economic results have been striking.

Actual experience in the coastal cities that have been opened has already shown that opening to the outside and importing technology is a shortcut to the acceleration of our technical progress, and that this national policy must be maintained over time, and certainly that we must not stop summing up our experiences nor stop improving.

At present, and regarding the importation of technology, there are some problems that we must look into, as well as earnestly resolve.

The first problem that warrants our attention is when we pay close attention only to the importation of equipment, not respecting the absorption of the technology.

The primary mode through which all areas in China are currently importing technology is the importation of equipment. Naturally, it is absolutely necessary to import certain key equipment or sets of equipment. However, the importation of technology is definitely not the same as just buying equipment. Right now, in the technology transformation projects of some provinces and cities, importing equipment (buying hardware) constitutes 99 percent of the activity, while importing technology (buying software) is only 1 percent, which has become a problem. This sort of problem occurs in the early period of importation, when it is perhaps unavoidable, but it requires prompt attention and conscientious resolution.

Japan after the war also depended upon the importation of technology to build itself back up. According to Japanese government statistics, in the 1950's Japan averaged an annual importation of 230 technical projects; in the 1960's it averaged 1,000 a year; and in the 1970's it averaged more than 2,000. By March of 1978, the Japanese government had imported 29,599 technical projects, coming from 40 countries and regions, but primarily from the United States and developed nations in Western Europe.

However, in the first half of the 1950's Japan imported just some key equipment and a few entire equipment systems, afterwards concentrating on the purchase of technical patents and design blueprints. In the early 1960's, the proportion of software that Japan imported had already reached more than 80 percent, and in the 1970's Japan further restricted the proportion of equipment imported (only a few percent). Why did Japan act this way? It is well worth our consideration.

The goals for Japan's importation of technology lay in promoting its technical progress. In the period from 1950-1975 Japan imported a total of 25,777 technical projects, and the cost of technical patent fees and fees for technical guidance totaled 5.73 billion US dollars. By the estimate of the Japanese government, had these projects been developed completely by the Japanese themselves, the necessary development expenses would have been $180-200 billion. This is to say that by importing technology the Japanese saved more than 95 percent of development expenses. The American Dupont Corporation spent $25 million to develop the nylon synthesis technology, with a development time of 11 years. Later, the Japanese Toyo Jinzoito Kokusai (artificial silk company) imported the technical patent for that technology for only $7 million, which was successful after 2 years of development and went smoothly into production.

We can see from this that when it came to importation, what Japan paid most attention to was not buying equipment but was the absorption and assimilation of advanced technology. The expenses used by Japan for absorbing and assimilating advanced technology was generally 2 to 3 times that of importing technology. During the period from 1955-1975, Japanese expenses for importing technology were 15 times higher, while expenses for research and development increased 74 times.

This goes to show that in importing advanced technology from abroad we must integrate with our own research and development, and with our own research and development as a base, closely integrate what is imported with absorption,

assimilation, and innovation. At the same time that we import technology, we want to innovate on the basis of absorption and assimilation from the points of thinking and organization down to the action level of absorption and assimilation.

The post-war historical experiences of the Japanese steel industry are well worth our study. During the 1950's and 60's, the Japanese steel industry imported more than 300 technical projects from abroad, and of the six great technologies among them, those of materials pre-processing, high-temperature high-pressure blast furnace, ejection of heavy oil, the oxygen top-blown converter, continuous casting, and continuous rolling, all were imported from either Austria, the United States, France, or West Germany. On the basis of its absorption and assimilation, Japan transformed and synthesized these technologies, creating the Japanese convertor steel making technology and the continuous annealing technology, the rights to which were then sold abroad.

At present, China's situation of low level repeated importation of equipment is a common occurrence. For example, many provinces and cities have imported clothing production lines, which must also use foreign currency to import materials. Because clothing designs (software) cannot keep up, some clothing production lines have either often stopped or slowed down. The technology for this kind of production line is certainly not advanced, and it is difficult to export the products to earn currency. Or take for example household appliances like color television sets or refrigerators, for which many production lines have already been imported. Each year great quantities of components and spare parts must be imported, the necessary foreign currency for which is many times that of the imported production line. Since the products are chiefly for domestic sale, they are lacking in competitive capacity on the international market, earn little currency, and if this goes on, deficiencies in foreign currency will continue to increase.

Imported technology must certainly work toward the acceleration of China's technical advancement, industriously improving the quality of China's products, improving the labor production efficiency for enterprises, and enhancing the competitive capacity of Chinese products in international markets.

Of course, importing a few clothing production lines, color television production lines, and refrigerator production lines to satisfy the ever increasing material and cultural needs of the public at large, even to the extent of importing some clothing and household appliances, is also necessary. However, we ought not to unlimitedly and repeatedly import this kind of equipment and commodities. We must take control macroscopically, and that equipment that can only earn money domestically and that has no capacity to earn foreign currency on the international market, does not generally merit large volume repeated importation. Through market forecasts and resource surveys, some cities in Guangdong decided to not import refrigerator production lines, but to import the technology, to bring in foreign funding, and to run marble factories, granite factories, and concrete factories to develop the local resource advantages, using commodities to exchange for foreign currency and pay back foreign investment. This kind of technology importation is worth mentioning.

Overall, what should we import? What should we not import? We need accurate strategic thinking as a guide, definitely cannot afford to not be choosy about what we do and import blindly, importing whatever foreign countries have to offer. Each city that has been opened and each economic zone must carefully and painstakingly study its own developmental strategies, determine their own development directions and focus, proceed from their own development requirements, begin deep investigation and research into foreign advanced technology, and then import that technology with a well thought out plan. Then, energetically take up the work of absorption and assimilation. All of this before foreign things can be made to serve China and accelerate the progress of our technology.

In this new situation of abrupt development of revolutionary technologies, there is the possibility that the economic and technical gaps between China and developed nations will continue to expand. We should have a sense of urgency regarding the importing of advanced technology to hasten China's technical advance and toward strengthening the competitive capacity of Chinese products in international markets.

Moreover, we should be fully aware that truly advanced technology, especially the newest achievements to improve the technical fields, will not be able to be imported. . In the view of developed countries, providing advanced technology to foreign countries is equivalent to digging one's own grave, and they will strive to stay 10 years ahead of us technologically. Therefore, the entire country, each city, and even each enterprise, must energetically enhance their own research and development, beefing up the research and development contingents.

Because of the limitations of our national strength, we cannot technically "completely catch up and surpass," but there are things we can do and things we cannot. The sophisticated technologies of fusion energy and space exploration are very important, of course, but their funding and manpower require a very strong real capacity, for which within this century China cannot gather its energies to tackle. It is not that we do not do it, it is that we cannot. Therefore, in these fields it would be hard to avoid an increasing technical gap with developed countries in the future.

To allow 1 billion people to live comparatively well-off lives, we must manufacture large quantities of good quality, low priced new products to satisfy the increasing needs of both urban and rural people in the areas of clothing, foodstuff, housing, and transportation. Presently, many material products needed by the public at large on a daily basis are far from being satisfactorily supplied, and the only way out is to depend upon technical advances, to take the shortcut of importing foreign advanced technology. Moreover, this technology is completely importable and our scientific and technical contingent is completely capable of absorbing and assimilating it.

Let's look at foodstuffs. Recently, Comrade Chen Yun pointed out that: "The people live day by day because of food, and if we provide nourishing, sanitary, convenient, and substantial foods for our people, this will be beneficial to our modernization." For these reasons, we must strive to import

modern food production technologies and greatly develop a modern foodstuff industry. However, our existing foodstuff plants can be largely said to be mainly manual operations. They cannot provide nourishing, hygienic, convenient, and substantial foodstuffs for the public at large. Therefore, each operation and household must expend a great deal of time in providing three meals a day. The key to our developing a foodstuff industry having abundant resources and expanded markets lies in importing modern foodstuff production technology. There are still in China a large number of uncultivated resources that could be used, as for example pollen, (CI LI), (SHA JI), (YUE JU), etc., which are materials that can be used for various highly nutritious food products, and as long as we are good at importing advanced technology for their processing, those products are entirely capable of entering the international marketplace.

This shows that if when importing foreign advanced technology we can combine that with the resource advantages of our own country, then the products can possibly enter the international marketplace and have a competitive capability. For example, China is richly endowed with rare earth resources, and if we can import without delay new technologies that use rare earth elements to make new types of magnetic materials, as well as to use these magnetic materials to make small package, highly magnetic electrical machinery, then it would be possible to enter the international marketplace.

The world new technology revolution presses us to hasten our steps toward technical advancement, requires that we undertake a full scale restructuring of our economic system, and makes the Chinese economic system have an even stronger capacity to assimilate the newest, current scientific and technical accomplishments, to motivate scientific and technical advances, and to gradually create new production forces. The reform has already broadened the road for an open-door policy and for the importation of technology, which has proven that importing technology is beneficial to accelerating advances in China's technology, and that it is beneficial to developing socialist production forces. We should boldly and firmly move forward on this shortcut to accelerating technical advancement!

12586
CSO: 4008/2023

NATIONAL DEVELOPMENTS

RADIO, TELEVISION PRODUCTION INCREASES

OW221420 Beijing XINHUA in English 1318 GMT 22 Jan 86

[Text] Beijing, 22 Jan (XINHUA)--China manufactured radios and television sets valued at 40.9 billion yuan (U.S.$12.8 billion) over the last five years, government officials said today.

Production grew at an average annual rate of 32.8 percent, reaching more than half of the electronics industry's overall output value, they said.

According to statistics from the Radio and Television Bureau of the Electronics Industry Ministry, last year alone the industry produced 14.3 million televisions--six times more than in 1980--and 10.7 million radio-cassette recorders--13 times more than five years before.

The Ministry also reported considerable growth in production of marine communication equipment, broadcasting transmitters, television signal translators, telephone switchboards and portable communication devices as well as microwave, satellite, telex, radio facsimile and cable communication equipment.

Over the last five years, China on its own has increasingly designed and produced complete communication systems--such as those needed on offshore drilling rigs--rather than manufacturing isolated items.

In addition, the country has developed several new devices for tracking and guiding satellites and missiles.

In the same period, China began a number of crucial projects, such as the building of its first color television tube factory, renovated one-third of its electronics production facilities, and imported several hundred items of technology to improve research and manufacturing. As a result, the diversity, quantity and quality of electronics products has increased substantially.

The technical level of some products has been raised to the international standards of the late 1970s and early 1980s. For example, color television sets average more than 1,500 hours of trouble-free operation. For radio-cassette recorders the average is between 1,000 and 2,000 hours.

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NATIONAL DEVELOPMENTS

OPINION ON IMPORTANCE OF S&T REFORM

Beijing RENMIN RIBAO in Chinese 14 Nov 85 p 5

[Article by Yu Weidong [0060 4850 2767] abridged from the original in KEXUE GUANLI YANJIU [RESEARCH INTO SCIENTIFIC MANAGEMENT], no date: "We Must Be Firm in the Restructuring of the Science and Technology System"]

[Text] I. If we are to solve the problem of the integration of science and technology [S&T] with economic construction, we must first solve the problems of principles.

For several years, the party working principles for science and technology have been in a process of adjustment and evolution. In March 1978, at the opening of the National Science Conference, Comrade Deng Xiaoping emphasized the view of Marxism toward science that "science and technology are forces of production," and to have linked science and technology directly with the development of production forces was the theoretical basis for adjusting the science and technology working principles. From 1980 through 1981, leading comrades in the Central Committee repeatedly pointed out that science and technology must develop in coordination with society and the economy, and that we were to take economic construction as our prime task. In April 1981, while making public the communique by the national science commission leading party group "A Report Outline Regarding Policies Toward the Development of China's Science and Technology," the CPC Central Committee and State Council pointed out that we: "will consider the development of the economy and of science and technology together with the development of society as a whole, and we will overcome the problem whereby there have been no links between them. Economic construction will depend both on social science and the natural sciences." "The categories of science and technology are many and they must serve all areas; but above all they must serve economic construction." In October 1982, Comrade Zhao Ziyang, while representing the party Central Committee and State Council at the National Science and Technology Awards Ceremony, made clear the strategic principle that economic construction must depend upon science and technology, and that science and technology must cater to economic construction. This policy of "dependence--catering to" explained the relation between economic construction in China and science and technology, and reflected the internal rules regarding economic construction and the development of science and technology. This principle is both a strategic principle to invigorate the economy and a strategic principle to develop

science and technology. The problem now is how we will implement and carry out this strategic principle of the party.

II. Implementation of the strategic principles of the Central Committee will be a long term process, and if we are to truly solve the problem of the integration of science and technology with the economy we must [illegible] all the four aspects of principles, policies, planning, and systems. In his speech before the National Science and Technology Workers Conference, Comrade Deng Xiaoping pointed out that "We must now go further in the problem of the integration of science and technology with the economy. What I mean by 'going further' is to say that after the problems of principles and [illegible] have been solved, we must still solve the problem of [illegible] system." "A new economic system ought to be a system that is beneficial to technical advancement. A new system for science and technology must be a system that is beneficial to economic development. We must work along both lines, for it is possible that the long term separation between science and technology on the one hand and the economy on the other can [illegible] satisfactory resolution." The resolutions passed by the Central Committee regarding restructuring of the economic system and the resolutions regarding restructuring of the science and technology system have manifested the spirit of "working along both lines" as expressed by Comrade Deng Xiaoping in his speech.

Regarding the resolution to restructure the science and technology system, the Central Committee has made four points of emphasis in the reform: 1) to change the funds allocation system for scientific research organizations. 2) to adjust science and technology structures, and to strengthen the development and research capabilities of enterprises. 3) to stimulate the commercialization of technical achievements, and to open up technology markets to suit the economic development of socialist commodities, which has been a big breakthrough for us in theory and in awareness regarding the [illegible] of technology. To forcibly open up the technology marketplace is a matter of extreme importance in the restructuring of the science and technology system, and is a powerful measure for opening the way for the [illegible] of technology to flow through the channels of production. 4) to change the personal affairs management system for scientists and technicians, and to create a social environment in which people will make the most of their talents. Restructuring the science and technology system is to liberate productive forces, and it is foremost to release the productive forces of science and technology. Scientists and technicians are pioneers in the new production forces, and what is most important at present is to give full play to the positive role of current scientists and technicians.

Some people have been concerned that in stressing the policy by which science and technology must cater to the economy, this will affect China's research in basic science and will affect the approach to key problems in the larger scientific research projects. And there are also people who are worried that after universal implementation of a commissioned contract system for developmental research units and some applications research units, they will develop a attitude of quick success and instant benefit, which will affect the progress of medium and long term research work. It cannot be said that there is no merit in this concern. If we do not do this well, it is possible that

[illegible] to some degree. In the process of drafting the "Resolution," [illegible] problems were examined deeply and the document was revised 10 times. More than 170 people were organized into more than 10 investigative groups for investigation into special subjects. These groups solicited the opinions of more than 3,000 specialists, scholars, and leading cadre, and organized more than 2,000 people in a discussion of the draft document. At the National Science and Technology Working Conference held in March this year, there was also a diligent and thorough revision of the draft document. The "Resolution" has made appropriate provision regarding problems that could occur, as for example, in stipulating that we must give proper attention to the in-depth plans for scientific research, that we must continue to carry out planning and management for the major national projects, that we must set a science funding system for basic research, and that we must carry out the expenses responsibility system for research units in standards, measurements, observation, information, and environmental sciences, etc. By diligently promoting these provisions we can guard against arbitrary uniformity, can avoid generating all sorts of side effects, and can bring the task of restructuring the science and technology system onto a track of healthy development.

Restructuring the science and technology system is a formidable project that will require leading departments of all levels to enhance their leadership, to guide carefully, and also requires that each area, each department, and each aspect be of one heart and one mind and make a concerted effort. We believe that after constant practice, summation of experiences, advancement, and improvement, the task of restructuring China's science and technology system is certain to be successful.

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NATIONAL DEVELOPMENTS

ANALYSIS OF NEW S&T HIRING SYSTEM

Beijing ZHONGGUO KEJI LUNTAN [FORUM ON SCIENCE AND TECHNOLOGY IN CHINA] in Chinese No 1, Sep 85 pp 57-58

[Article by Wang Kang [3769 1660]: "Some Problems with the Hiring System"]

[Text] The resolution by the Central Committee regarding the restructuring of the science and technology system clearly pointed out that we must restructure the science and technology personnel management system, and that we can gradually try out a hiring system in research and design organizations and for higher level institutions. Before this, the hiring system had already attracted the attention and comments of scientific and scholastic circles, and had as well achieved excellent initial results at test sites at several units throughout the country. Of course, it needed more testing, and especially to bring forth a set of rather complete policies and methods based on testing over a much larger scale. The central authorities have now made the testing of a hiring system within a certain scope to be an important matter in the restructuring of the science and technology personnel management system, which has even more attracted the attention and explorations of various aspects. In this paper I present a few superficial views for the benefit of personnel studies and personnel management.

I. The Function and Purpose of the Hiring System

For a long time now we have treated the management of scientific and technical personnel the same as party and government cadre, using the same methods, namely, planned assignments, organized transfers, and administered management. For the past few years, although we have undertaken a few improvements and reforms based on the characteristics of scientific and technical personnel, the management system, and especially the administrative system, are still basically in the old modes and old models.

Putting a hiring system into effect is not only beneficial to further breaking up the communal pot and overcoming abuse of the "iron armchair," but also can play a determining and even irreplaceable role in advancing the reasonable movement of talent. This is because in implementing a hiring system each unit has the authority it ought to have for utilizing personnel, and it can overcome the currently commonly existing phenomenon whereby a person that a unit wants cannot be transferred in and people that the unit does not want

cannot be transferred out. The hiring system can also strengthen the capacity for self transformation and self development by the units in the aspects of talent and intellect. Because scientists and technicians themselves will be given a certain amount of authority to select their working positions at the same time that a hiring system is implemented, this will get past the barriers of "unit or department ownership," and will be an opportunity to get work positions that will fully develop their own abilities and their contributions to the nation. Similarly, implementation of a hiring system will create a situation of competition for talent, which will both create a respect for knowledge and a respect for talent by all parties, and will also allow scientists and technicians to grow within competition, as well as give the opportunity for a few top-notch people to emerge from obscurity. Overall, putting a hiring system into effect under the guidance of national planning could greatly enhance the role of social regulation, strengthen the flexibility and vitality of the science and technology personnel management system, and could fundamentally change the ossified state where there is unity to the extent of suffocation and isolation.

II. The Nature of the Hiring System

First, it is not a system for the hiring of labor. The hiring system that we will employ is fundamentally different from the labor hiring system of capitalist countries. The nature of the capitalist hiring system is that the laborer (including either physical or mental laborers) do not own the means of production, and can only sell their own labor force as a commodity to the capitalists or capitalist groups who own the means of production. But our hiring system will be built on public ownership of the means of production, whether that employment is through national or collective units, and both the employee and employer are the joint owners of the means of production. Politically, too, they are both masters of society and of the nation. Both parties to hiring activities will use the means of contracts or employment agreements or employment documents to stipulate the individual responsibilities, authority, and benefits that must be complied with, where both parties are in completely equal positions.

At the same time, our hiring system is under the guidance of national planning. The contents of contracts and employment agreements must suit the requirements of national planning and national policy and laws. This will also ensure that our hiring system is socialist in nature and is not the capitalist labor hiring system.

Second, will we be creating a free movement of scientific and technical talent, or what is called the freeing up of talent movement? I do not think so. The superstructure that is the personal affairs and cadre management system was determined on an economic basis, and also serves it. Scientists and technicians are exploiters of the new production forces, and the scientific and technical labor force is an important component of socialist production forces. Therefore, the scientific and technical personnel management system is intimately connected with China's economic system. China's economy is a planned commodity economy and is not a market economy. In economic fields, planned guidance, regulation, and management are in dominant and controlling positions. The hiring system that will be an

important part of the scientific and technical personnel management system must also be guided and managed by state planning. The state has provided for reasonable channeling, and demands that hiring activities must coincide with the requirements of channeling. The scientists and technicians needed by the larger economic construction, defense construction, and scientific research projects must in the main or to a great extent be assigned by planning, especially for those key elements among them for whom there must be planned deployment with guarantees, and the assignment of college graduates and students who study abroad on public funds, to ensure the proportional development of the national economy. Therefore, our hiring system is certain not to create an anarchical freedom of movement.

Third, our hiring system has provided for relations between individuals and groups regarding employment for scientific and technical labor through contractual or employment agreement modes, and has as well provided for relations between the state and groups and individuals in these aspects through the guidance of national planning and policies and laws. This has allowed for the close integration and the organic unification of the needs of national planning with the hiring authority that units ought to have and with a certain amount of say in the choice of work place by the individual. Therefore, the nature of our hiring system is that it is a system that serves a positive function for and management of scientific and technical labor (which of course is scientists and technicians). Because it regulates the relations involved in the utilization of scientific and technical labor between the state, the group, and the individual, it is an important reform of the scientific and technical personnel management system.

III. Implementing the Hiring System is a Necessary Trend

We lack experience in running a hiring system under socialist conditions. We must proceed cautiously, make measured experiments, gradually expand them, and therefore perfect it. However, there is an objective basis for a hiring system, and it is a necessary trend. Therefore, at the same time that we are proceeding cautiously in a tactical way, we must be resolute strategically. The objective basis for the hiring system and its necessity are evidenced in the following:

First, the hiring system meets the requirements of China's economic system reform and the restructuring of the science and technology system. In implementing the reforms in those two systems, there will be in both cases an expansion of autonomy for enterprises and scientific research organizations, which will allow them to become relatively independent operational entities. The most important thing about autonomy is the authority for personal affairs. If they do not have the authority for personal affairs that they ought to have, they cannot resolve obstacles to the movement of talent. And when expanding enterprises, as well as developing scientific research organizations for research and partial applied research, it will be difficult to survive and plan for development in the competition of commodity and science and technology markets, and it will be hard to take on the responsibility for the particular profits and losses and for independent operation. Because of the competition in commodities (be they material or intellectual commodities), what is at the root is competition between talents. Also, the new world

technology revolution is just now exploding, where renewal of commodities and technology is quickening daily, a challenge China is just now facing. Enterprises and research organizations must have a flexible response to this, and making use of the rightful authority over personal affairs, must constantly and in good time improve their own personnel and intellectual structures and strengthen the competitive capacity of products. The hiring system is a good means by which to meet the demands of this trend.

Second, the hiring system conforms to developing trends and demands in modern science. The trends in modern science toward both high degrees of differentiation and high degrees of synthesis demand that scientists and technicians expand their knowledge on that basis, that they constantly renew their knowledge and derive new academic theories and that research organizations and relevant units and departments undertake alignment and realignment by various classifications and on various levels based on the needs of scientific and technical development and in the aspects of talent structures, specialist structures, and intellectual structures. By putting a hiring system into effect, we can completely break out of the situation by which there is separation and barriers between particular departments and particular units. This will allow them to change from an isolated form to one that is open, which will accelerate the rational movement of talent, put a stop to "inbreeding" and ideological ossification, and develop "cross breeding of superiorities" and an innovative spirit.

Third, the hiring system has been determined by the characteristics of scientific and technical labor. Scientific and technical labor is a complex and creative mental labor. Its demands on the subjective factors of the interest levels and aspirations of the scientists and technicians themselves as well as on the objective conditions of working conditions and environment (including having reasonable intellectual structures and harmonious social relations) are much higher than for general physical labor. These subjective and objective conditions often have a decisive influence on the motivation and creativity of scientists and technicians. For example, some materials indicate that if scientists and technicians lack interest in their work, they can only operate at from 20 to 30 percent of their abilities. Of course, interests and aspirations can be changed. Those interests and aspirations that do not suit the demands of society and the nation ought to be dredged and corrected, but we should respect the proper aspirations and interests of scientists and technicians to more fully develop their creative capacities. Regarding the working conditions and environment needed by scientists and technicians, because of such factors as the rapid development of production specialization and division of labor, as well as technical innovation and the pace of the technology revolution, etc., to which is added the differences in the stages of maturity of scientists and technicians, things often happen because of people, or events, or the times, which makes them extremely complex and varied. Consequently, reasonable movements must proceed through unblocked channels that allow each person to achieve the required conditions and environment to the degree possible to fully develop their motivation and creativity.

Fourth, the hiring system suits the characteristics of Chinese labor. Our socialist system has public ownership of the means of production as its basis,

where "laborers participate in labor as full fledged members of a society in joint ownership of the means of production" (Footnote) (for this and other quoted material, see Xue Muqiao [5641 2550 2890], "Studies on Problems in the Chinese Society and Economy," chapter 4, section 1). "The relationship between laborers and society is already the same as that of all members of a group with that group." "Their labor has a directly social nature." Which is to say, their labor has already combined to be the public labor of society, which then has a public quality about it. At the same time, and in another sense, labor is a means of an individual's particular life, and "society cannot but tacitly agree that differing capacities for work are owing to the natural peculiarities of individuals, and between society and individual laborers there must be an exchange of equal labor and equal commodities. Speaking from this sense, society and the individual laborer are possessers that differ." "After the means of production became public, traces like this of the old society are retained in great measure by individual laborers." Our hiring system--the hiring system under planning and guidance, will both provide for the individual scientist or technician the right to select a working place and for the relevant unit an autonomy in hiring people, and will also allow these rights to be placed under state planned guidance, regulation, and management. It will allow them to be maintained within the limits of what we discussed before as "a certain measure of" and "rightful," which is just the scope permitted by state policy and laws. To do it in this way will suit this nature of Chinese socialist labor where there is both a public ownership and a portion of individual ownership that has been retained. Consequently, there is historical necessity in the implementation of a hiring system.

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NATIONAL DEVELOPMENTS

HIGHER INSTITUTIONS IN S&T MARKETS DISCUSSED

Tianjin KEXUEXUE YU JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 32-36

[Article by Tao Weijiang [7118 5898 3068]: "Some Reflections on the Function of Higher Level Institutions in the Technology Markets"]

[Text] Socialist technology markets have been formed through the state, groups and individuals, and the integration of autonomy in technology trade and the support of administrative departments. Their appearance breaks up the former science and technology [S&T] situation whereby science research, production, and the economy were divorced from each other, and they create the conditions in which to resolve the abuse of having "two skins" over science and technology and economic construction. Also they have accelerated the movement of talent and the circulation of technology. Technology that circulates in the form of commodities will also propel forward the restructuring of the science and technology system, as well as the dissemination, improvement, and transfer of science and technology. Therefore, the future of technology markets is expansive, and of great hope.

China's higher institutions have assumed the dual functions of training high level specialist technical personnel and of developing science and technology. There are at present more than 390,000 teachers and science research personnel, among which are one-half of this country's high level intellectuals. They are training 80 percent of the nation's graduate students, including both the social and natural sciences. The curriculum is complete and there is quick access to scientific and technical information, and there is as well the capability to organize more classes, to solve comprehensive major problems in science and technology, not to mention the ability to open up new products, new technology, and new techniques for small to medium enterprises. Up until now, higher institutions have been awarded 56 prizes in the natural sciences, which is 45.2 percent of those awarded in the natural sciences, and have been awarded 221 prizes for inventions, which is 24.4 percent of those given throughout the country.

However, on the other hand there are still problems when one compares the abundant real technical capability with the effect on the technology market of enterprises, companies, and research academies (institutes) and also its direct role on social and economic development. The author feels that applied

science research in higher institutions should pay close attention to the following points.

I. Take the initiative in developing projects that are "short, balanced, and quick."

Currently, town and township and privately funded enterprises are developing quickly, but they remain technically weak and deficient in capital. They can only hope for large projects and large products but cannot attain them, even if larger enterprises have no particular interest in them. Especially for longer term projects and products, in fear that funds might lay idle too long, medium to large enterprises cannot keep up with changes in the market. Therefore, there is often the situation where medium to large enterprises are not very enthusiastic about the application and dissemination of scientific and technical achievements, but neither can small enterprises accept them (due to funding and technology factors); when the rights to technology are transferred, they dare not put up the capital, and even with the amount shared several ways they fear they will lose out, so it is difficult to make deals. But those small projects and small products where investment is small, development time short, results are quick, and there is a market for them, they just fit the demand and are taken up in a moment. The situation for higher institutions is often like this: some teachers are good at the theoretical research of basic science, and publish several papers each year; whereas, other teachers are better at taking on applied topics, and therefore, the science and technology management departments of higher institutions should emphasize both basic and theoretical research and research into applied topics. Based on market demands and market adjustments, they should organize those teachers who are good at dissemination of applications to take the initiative in developing short term, balanced, and quick projects. They can even adopt various formats of responsibility systems to attract teachers into taking up applied research, and directly serving social and economic development.

II. Earnestly aim at applications, be conscientious about substantial results.

Higher institutions ought to have intellectual reserves, and ought to have about 60 percent of their capacity engaged in the theoretical research of basic science, and based on the specialties of the school, can establish classes that focus on research, and within several years or a decade there will be breakthroughs to enter the ranks of international or domestic advanced levels. At the same time as this, about 40 percent of capacity should be put into actively taking the initiative to develop research into application topics, and to provide even more new products, new technologies, and new techniques for opening up the technology markets. This is also for accepting topics through various means that industrial departments encounter in actual production, that is, topics outside of planning. And, to constantly lead reserve knowledge or technology through horizontal relations to production departments, to feed technical difficulties from small to medium enterprises back to the schools, and to organize strength into making short term breakthroughs, allowing the potential of both parties to be fulfilled. When transferring the rights to technology, they should work toward perfecting one,

then transferring one, and should evaluate the maturity of any technology from the point of view of society, the market, and applications. Trade may be done through an intermediary, which causes the market to be even more dynamic.

III. Directions should be flexible, policies should be implemented.

It is recommended that we draw on the experience of privately run technology institutes and science and technology development companies regarding the flexible and expedient, yet sound methods to develop technology markets. They are not limited to a certain field or a certain discipline, but do whatever the market needs. They do not need a state allocation system, nor do they need state allocated expenses, for on the one hand they take on research topics that are needed by the market, and on the other, organize their scientific and technical capacities. When things have been sized up, they act, when projects are completed, they let them go. Scientists and technicians get paid according to their efforts, and profits are distributed according to the degree of technical advancement and the degree of difficulty, as well as the degree of contribution toward completion of the project. This kind of management method is similar to the way some higher institutions plan application research topics based on disciplines, but is also different. Where it is similar is that things are tailored to capabilities; where it is different is where one person can measure the cloth to fit the body, but another does not do it that way. As the technology market develops, application development must be social, comprehensive, and flexible, and must accelerate cross fertilization and permeation of disciplines, as many projects will transcend departments and disciplines, and even the scientists and technicians that are involved in a project will be from different units and different categories. For these reasons, the technology markets have posed new demands for science and technology management in the higher institutions. Science and technology management includes the determination of research directions and planning, and the implementation of corresponding policies and measures. For a long time now, technology has been rather backward in many production fields, and the capability for large scale production of inexpensive, high quality products has been low. When the reasons for this are discovered, it is found that it is because intellectual labor and its material value have not been acknowledged, and even less has it been taken onto the track of commercialization. The appearance of technology markets and the commercialization of technical achievements have brought convenience to the implementation of science and technology policies.

As awareness of science and technology markets deepens, as long as directions are flexible and policies are implemented, the function of higher institutions in the technology markets will go up another story.

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NATIONAL DEVELOPMENTS

CRITICISMS OF S&T SITUATION IN HIGHER INSTITUTIONS

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENTIOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 33-35

[Article by Tao Xinliang [7118 9515 5328], Office of Science Research, Shanghai Industrial College: "Some Viewpoints on Science and Technology Development in Higher Institutions"]

[Text] I.

Higher institutions rely upon the comprehensive technical advantages of their full and complete curriculum; they rely upon the comprehensive advantages of having many teachers, graduate students, and undergraduates; they rely upon the comprehensive information advantages from their vantage point among developments in technology and as a site for the collection and dissemination of science information; they rely upon the comprehensive development advantages from both science and technology service and talent in cultivation. With intellectual investment as the primary form, with technical output and talent cultivation as the primary means, they have become a major force in the cause of science and technology development, and have become a very vigorous and important power in the technology markets. But as the markets have abruptly risen and quickly developed, scientific and technical development in the higher institutions has both had its own advantages and characteristics, and its new problems.

1. They are faced with a fierce and unprecedented competition.

The forceful opening of the technology markets is manifest in the daily bustle of both buyers and sellers. On the one hand, with the abrupt rise of town and township enterprises, the rapid development of small to medium factories, and the great advances in economic construction, the requirements of scientific and technical achievements were expanded, and buying capacity and potential for technology by buyers increased. On the other hand, there were also great changes in the conditions of the sellers. Currently, the main powers actively putting technical achievements out on the technology markets are not just the science research organizations and the higher institutions; there are also various hierarchical science and technology development companies and centers that are horizontally aligned and non-governmental. And there are science association systems and systems of trade unions and technical associations,

and some medium to large, and even small, factories have been setting up their own technology development departments or third production structures, all of which have joined the ranks of sellers in the technology markets. Industrial and mining enterprises have relied upon their own mature production technologies and abundant economic capacities, and through the channels of joint operations of production, technology output, sending out the processing of components, and providing materials and markets, they have become more vital in the technology markets; science associations and technology associations use the advantages of their talent networks and generous economic remuneration to attract a number of technicians to engage in science and technology development; private science and technology development companies even more rely upon their flexible operations and adaptable economic means to make the most of the potential in technical talent from everywhere in society, including the higher institutions. With so many forces out there, science and technology development in the higher institutions is faced with a precipitous battle line and very fierce competition.

2. There is an unfortunate tendency for an outflow of intellect.

Science research and development at higher level institutions has in recent years been struck in succession by three great influences due to the fact that the economic treatment of teachers is uneven. These have been jokingly called "the three waves." First: the gap in economic remuneration between science and technology development projects and projects from planning has grown steadily wider, the former because of deductions in net income, as well as because the proportion of the deductions has continued to rise (for example, at this school it has gone from 4 percent to 10 percent, and then to 17 percent), and the latter because they have not charged a single cent, and although some schools have adopted methods to "supplement internal deficiencies with outside help," these have been totally inadequate measures. The gap between the respective economic treatments of these two things has reached the point where some teachers have begun to "treat internal planning lightly, while emphasizing external planning." This has weakened the reasonable structures in science research in the schools, as well as the technical reserves for science and technology development. The second "wave": the majority of teachers are members of learned societies affiliated with science associations at all levels, and some years ago the science association system raised the portion of economic income from science and technology development received by individuals to 30 percent, and some have covertly tried to make it even greater. The tendency for some teachers to "emphasize science associations and neglect teaching" has caused a number of science and technology development projects that could have been taken on by schools to be shifted to science and technology associations at various levels, with the result that although the schools produce intellectual and material resources, the science associations obtain the material benefit and success. The third "wave": an upsurge in having work in addition to one's job, which some have called "the second occupation." Higher institutions used to have strict limitations on the question of teachers having concurrent work, as for example where it was ruled that sparetime part-time jobs had to be approved by the unit, and a proportion of the income obtained thereby was taken by the unit to take care of neighbors, etc. The "Resolution Concerning Restructuring of the Science and Technology System" once again pointed out that "with the

prerequisite that scientists and technicians complete their own work and not infringe on the technical rights and economic benefits of their unit, they may engage in technical work and consulting services in their spare time, the income from which will go to themselves; if the technical achievements and internal technical materials and equipment of the unit are used, that unit must agree to said use, and a portion of the income turned over to the unit." Macroscopically, this measure is undoubtedly beneficial to developing the enthusiasm of scientists and technicians, and to accelerating advances in science and technology and in the development of economic construction. But from the school's view of microscopic management, this will be difficult to get a precise hold on. Teachers do not have a strict schedule, and they cannot, as can industrial and mining enterprises and research organizations, put a clear boundary around 8 hours. Intellect and knowledge is a formless valuable product residing within the minds of teachers, and it would be very difficult to simply put on clear marks like "this belongs to the unit" and "this belongs to the individual," much less where there is no clear provision that sparetime part-time work be put on the unit's records. Therefore, the schools find it difficult to know and determine whether the individual has violated the technical rights and economic benefit of the unit, so how is it to know whether internal technical materials have been disclosed? Schools cannot understand this. This has led to the tendency where some teachers have "emphasized the part-time job, while neglecting their own."

"Emphasizing external planning over the internal"; "emphasizing science associations over the schools"; emphasizing the part-time job over the primary one," these three "waves" have resulted in a considerable portion of the intellect of schools being drained away.

3. There has not been a respect in fact corresponding to that in name.

Higher institutions are called one of the fifth route armies, but in fact have not received a sufficient amount of respect corresponding to that. It is, on the one hand, not like Chinese Academy of Sciences and local science academies, which can be supported by leading departments of all levels; nor is it like with research organizations in departments of the industrial and communications industries, that are supported by economics commissions, and in catering to factories have abundant financial resources for backup. When relevant leaders are dealing with large research development projects, what they think of first are the science academy system and affiliated research organizations; local industrial departments always think first that "rich waters should not flow to the houses of others," and confine their efforts to localities, taking care of research or development organizations run by the organization itself. It is always the case that only ungnawable hard bones and inedible chicken ribs and tails are turned over to the higher institutions.

Also, when some industrial departments import foreign advanced technology and equipment, they invariably neglect the high level capacity for assimilation and absorption possessed by higher institutions and science research organizations, and if they do not cast higher institutions to one side, they put them into secondary positions; higher institutions must cater to economic construction, but cannot "squeeze" into the higher echelons of scientific and

technical development circles, into which advanced technology is absorbed and imported. They can only frustratingly chase after what is left, and cater to town and township enterprises with greater effort and take up work in the lower levels of science and technology development. If this goes on for a long time, it could create the following consequences: on the one hand, industrial departments will have lost the support of the scientific and technical capabilities of higher institutions, dragging down the process of absorbing imported technology and affecting the results from that absorption, even to the extent that they cannot give full play to the function of foreign advanced technology and equipment; sometimes, there is inappropriate repeated importation, which increases the expenditure of foreign exchange. On the other hand, higher institutions have therefore lost out on a valuable means of making contact with international advanced technology, and the level of science research cannot take advantage of an even greater boost, and sometimes it even happens that science research at higher institutions falls behind that of the level of technology already imported.

II.

How can we maintain and strengthen the capability for distillation of science and technology research at higher institutions?

1. Maintain the appropriate proportion of science and technology development funds, and increase encouragement economically. For the individual, there are four choices placed before the teachers at higher institutions: A. carry on in the capacity of the school, and when finished with a project, 14-17 percent of the net income should be deducted according to the particular provisions of each school as individual remuneration. B. Attach oneself to science associations, and deduct individual remunerations from 30 percent of net income according to science association provisions. C. Through the channels of private development companies, after completion, it is only necessary that they take 20-40 percent for management expenses, and the rest of the net income can be returned to individuals. D. Take on a spare time job directly with town and township enterprises or group units, the net income from which would nearly all go to the individual, or, as an alternative, he would receive a concurrent wage of the same amount. Among the four choices above, the deductions for the school itself are the least amount, but higher institutions still have the economic levers of increasing wages and promotions to maintain their momentum, attraction, and their distillation capacity. The proportion of money given to participants in technology development at higher institutions ought to be raised, or otherwise there will be a further increase in alienation, which would increase the tendency for intellect at higher institutions to flow away.

2. Provide for necessary procedures for managing concurrent jobs, and be more restrictive in discipline.

Seeing that teachers at higher institutions have no real 8 hour limitation, and that even including the quality of teaching and the amount of work done in research is a method that still lacks perfection and accuracy, therefore, when concurrent jobs are not approved by the units it can result in a few teachers "being on the job but their minds are elsewhere," a situation that cannot be

controlled. It is recommended that provisions be made that sparetime part-time jobs by teachers at higher institutions be subject to approval by their units to more easily maintain the capacity for distillation of the science and technology development in higher institutions, and to reduce the outflow of intellect.

3. Enhance the self-building of higher institution science and technology development operations contingents.

Self-building of higher institution science and technology development operations contingents include two items. One is the improvement of the quality of the entire structure; the second is to arouse the enthusiasm of operations personnel.

Aside from deducting a certain percentage of economic income to encourage operations personnel in science and technology development, the prompt resolution of posts (academic rank) problems for operations personnel in science and technology development is an important measure for arousing the enthusiasm of those operations personnel. Operations personnel in science and technology development are just like people in research management and instruction management in that they are all professionals. Since we admit that management science is a large science, then why does management not share corresponding posts (academic rank)? We must change the erroneous conception that looks down on operations. Evaluation of the posts of specialized management workers ought to have different standards, should form a series of their own, ought to be based on the characteristics of specialist management workers themselves, and should be formulated as quickly as possible according to the relevant standards of other position series. This is also a necessary condition for science and technology development to have connections outside itself.

4. Coordinate well the science and technology research organizations of higher institutions with science research management organizations.

The original science research management organizations in higher institutions are an office level organizational system--the office of science research. In recent years, there have been two types of science and technology development organizations that have emerged, one being the earlier science and technology service department (science and technology development department), and the other kind is the recent science and technology development company. But the science and technology service department is subordinate to the office of science research, in other words, two names for just one group. We believe that: 1. there is a great deal of science and technology, procedures are complicated, and responsibilities are great. Therefore, structures should not be too small, and for the allotment of personnel there should be guarantees for a certain number of them and their quality. 2. Science and technology development companies and science and technology service departments are best managed together, for if the two are separate it will not be conducive to the

overall planning of the school science and technology development, nor for overall arrangements. 3. Science research and science and technology development are two important links tightly forged together in a chain. Their relations must be strengthened, organically integrated, and they must never be severed.

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NATIONAL DEVELOPMENTS

SUGGESTIONS FOR REFORM OF COLLEGE S&T RESEARCH

Tianjin KEXUEXUE YU JISHU GUANLI [SCIENTOLOGY AND MANAGEMENT OF S&T] in Chinese No 11, 15 Nov 85 pp 32-36

[Article by Shuai Xiangzhi [1596 4161 1807], Office of Science Research, Shandong Shifan University: "Science in the Higher Institutions Is in Urgent Need of Reform"]

[Text] China's economic, science and technology [S&T], and education systems are currently faced with a new trend toward full-scale restructuring, and restructuring of the science and technology systems at higher institutions is also gradually developing. These reforms are of great significance to building China's four modernizations. Reforming scientific research at higher institutions is also an important aspect of this.

I. Reforming Science Research at Higher Institutions Will Suit New Trends in Economic Development

Since the founding of our nation, our higher institutions, and especially those affiliated with major academies, have made important contributions to economic and cultural construction, and some of the research achievements they have made have already been applied in actual production, and, what is more, have gained important economic and social results. However, because they have long been affected by "leftist" influences, the phenomenon in which the science research at higher institutions has been divorced from production has been all too serious. Just looking at the 1984 statistics from two major comprehensive colleges in Shandong alone, we can see that there was no direct relation between 60-70 percent of science research projects and production. Science research at higher institutions, and especially in applications and development research, has not received the attention it should have.

The CPC Central Committee pointed out long ago that "Higher institutions are both centers for education and are centers for science research, and they are an important front army for science research." The "two centers" points mainly to the social function of higher institutions, that is, the position and function of higher institutions in building toward modernization. To see the "two centers" as dealing with only teaching and research in higher institutions would be incomplete.

Currently, if science research at higher institutions is to concentrate on applications and development, then it must take as the goal of its topic selection the promotion of technical advancement, technical transformation, and the renewal and updating of products in industrial and mining enterprises, as well as importing, absorption, and assimilation. By joining higher institutions with factory and mining enterprises, we can make use of the methods of voluntary participation and mutual benefit and multiple formats: 1. to accept commissions from industry and factories through the channels of the technology markets and science and technology trade fairs, sign contracts for specialist projects, help research new products and new techniques, or by representing the development and provision of key equipment; 2. cooperatively undertake technical troubleshooting. Science and technology is a strongpoint of schools, and manufacturing and technique are the strongpoints of factory and mining enterprises. If the two cooperate, they can reduce research times and hasten the transformation of achievements into direct production forces; 3. establish joint research and production groups. With the schools taking on research, design, and experimentation, the factories can do processing and trial production, as well as provide a certain amount of research expenses to the schools. After the achievements have been appraised and are in batch production by the factories, the schools would deduct a percentage from the amount of annual sales (or annual profits). Working this way, we can quicken the research pace of schools, accelerate the transfer of achievements, and increase income; factories can also renew their products, improve their capacity for competition, and greatly increase their profits.

II. Implement a Research Topic Contract Responsibility System, Improve Benefits from Investment

By implementing a research topic contract responsibility system, we would organically combine the benefits for the state, units, and individuals with the responsibility, authority, and benefits of the research group and individuals. This would be beneficial to arousing the enthusiasm of the majority of teachers, would improve work efficiency and investment results, and would be a good method worth trying. But schools are not the same as factories and agricultural and specialist research institutes, so a research topic contract responsibility system cannot be implemented in one fell swoop. We must consider the characteristics of schools and the nature and source of responsibility for research topics, and adopt a corresponding research topic or responsibility contract system.

The most important sources of research topics for higher institutions include: directive planning by the National Science Commission, ministries in the State Council, regional science commissions, and relevant provincial departments, National Science Fund topics, and contractual commissions by factory and mining enterprises. In carrying out topic planning, because topic responsibility is clear for factory commissions, division of labor is specific, and rewards and punishment clear, tasking completion is somewhat better. But projects that are included in the planning of the state and regional science commissions are often not completed on time. Some schools favor seeking out directive research topics for the economic income to the particular unit. They have not given sufficient attention to planning arrangements, selection of personnel, and scientific and technical conditions,

and to the necessary guarantees. On the contrary, they concentrate all their resources on those "immediately beneficial" topics that will increase income. The result of all this is that although they can provide new products and new techniques for factory and mining enterprises, as well as allow the researchers themselves to have more economic income, and teachers can obtain more reward money, this all adversely affects the completion of national science research planning. According to statistics, 16 higher institutions in Shandong ought to have completed 25 provincial science commission planning projects, but actually only finished 8, or 32 percent.

Everyone knows that nationally funded science research planning is determined by overall planning of the national economy, and is tasking that is concerned with the whole. If this kind of tasking is not completed, this will lead to national and social losses in technology, and sometimes these losses are extremely serious. Therefore, any unit implementing any kind of responsibility system must first assume national science tasking, and ensure that it is completed on time, with sufficient quality, and in sufficient quantity.

Based on the differing natures and sources of the topics that higher institutions take up, for directive planning an enforced planning responsibility contract system may be implemented; for projects commissioned by factories, a topic contract responsibility system may be used. But no matter what the form of the responsibility system, the responsibilities must be made clear, the times for completion and qualities should be clarified, and the rewards and punishments made clear. When topic tasking has been completed, research units and individuals may both receive a certain economic income.

If directive scientific research topics implement an enforced planning responsibility contract system, it can be done so that the school (office of scientific research) signs enforced planning contract documents with each department or institute. The contents of that contract would include: the research subjects, technical requirements, progress arrangements, personnel participating, required conditions (expenses, materials, instruments and equipment, and experimentation sites), and methods for reward and punishment. After the contracts have been signed, the topic group will formulate particular working plans, will place certain responsibilities on people, and will guarantee the on-time completion of the planned tasks. Based on the contract requirements, the school should allocate funds and materials promptly to the topic group. For that research tasking that is completed on time, and also that has outstanding economic or social benefits, or is at a higher academic standard, the topic group and individuals should be rewarded appropriately in accordance with award clauses. Award funds may be taken from a proportion of the research expenses for that project. For those projects not completed according to plan, and where there is no objective reason, this should be taken as the responsibility of those in the unit in charge and of the topic responsible persons, or a portion of the research expenses should be taken back, and they cannot apply for new projects for a certain time.

For topics that are commissions from factory and mining enterprises and that have been obtained through the channels of technology markets and science and

technology trade fairs, responsibility contracts can be signed between the departments or institutes and the topic group or research laboratory. The contents of the contracts can be according to the needs of the factories, but should include clarification of responsibility, the division of labor, and punishments and rewards. We want to be responsible to society, and want to allow the achievements of research to truly produce economic results and to be worth the practical experience. To improve the returns on investment, schools should use project research funds or development funds that have been arranged within the school, or they can also implement bidding for topics and contracts for compensated usage.

III. Expand the Autonomy of Research Institutes and Laboratories

The phenomenon in higher institutions of "too secure, with stifling control" has been quite serious. When research units at higher level institutions have no authority over personnel or financial affairs, and there is a lack of vitality in economic construction, this sort of situation impedes the development of personnel intellect and creative abilities, nor is it a benefit to producing either achievements or talent. The author believes that reform should be undertaken in the following aspects:

1. There should be a certain amount of authority over personnel by research organizations. Research institutes would implement institute director responsibility systems, where institute directors have the authority to decide on facilities for organizations within the institute, and the authority to appoint or dismiss cadre. The deputy director can act in the name of the director, reporting to departments at higher levels for approval of appointments.

Within the research institute there should be freedom of organization for the topic groups, and there should also be gradual implementation of an employment system. The hiring system would chiefly operate within the institute, but based on the needs of the work, the institute could also go outside the institute to hire scientists, technicians, and technical workers, and can as well recruit graduate students and college students to participate in the research. As for those who are unemployed or are being sent away from the institute, there is the authority to make other arrangements and to aid in separation.

2. Research units would have the authority to use funds. We would change the troublesome method of the past in which spending even 1 yuan required signatures from the lab, the department (institute), and school. Use of science research funds an be done with three level control, namely, the school, the department (institute), and the lab or topic group. Anything at 2,000 yuan and below can be approved by responsible persons in the lab or by those responsible in the topic group; 5,000 and below can be approved by department (institute) the respective persons of responsibility; 10,000 and below can be approved by the office of science research (outlays above 10,000 yuan must be submitted to the responsible institute director). Science research development funds earned by the research institute may be arranged in general by the institute director for use primarily in laboratory construction and in arranging projects selected by the institute itself.

3. Science research organizations should have the vitality to cater to economic construction and the needs of society. Under the premise of ensuring completion of assigned science research tasking, we should permit departments (institutes) to integrate the research directions of a unit, fully using their own technical capabilities and conditions. On a contractual basis, commission other units for the tasks of research, experimentation, trial production, and technical processing. Also, on the basis of the compensated transfer of rights to technical achievements, sell small and medium trial products and develop technical servicing for the outside to generate economic income. Specialist research institutes should operate science research production models, both for study and for batch production, to gradually reduce the service fees that are provided by the state.

4. Those responsible for research institutes and laboratories should have the authority for rewards and punishment. Those responsible for research institutes and laboratories should establish a certain awards fund to reward outstanding accomplishments in research and in dissemination of achievements, to reward the greater contributions to economic construction and to society, and to reward scholastic innovations, and greater rewards for the most outstanding. Also, in the aspects of housing and living amenities, these accomplishments should be reported to relevant departments for appropriate consideration. There should be economic punishment for those who do not abide by distribution, and for those who cannot complete research tasking when there is no objective reason.

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NATIONAL DEVELOPMENTS

PROGRESS REPORT ON CHINA'S NEW PATENT LAWS

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 2 Nov p 3

[Article by Chen Naijin [7115 0035 6651]: "China's Patent Laws Have Stimulated Inventions and Creativity"]

[Text] Beijing, 30 Oct, Xinhua--In the nearly 7 months that China's patent laws were in effect from 1 April of this year through 26 October, the China Patent Office had received 11,609 patent applications of three types: inventions, new types of applications, and designs.

This was reported by Huang Kunyi [7806 0981 4135] at the opening today of the Beijing Conference on Industrial Property Rights. He said that for several months not only has the volume of patent applications been much greater than anticipated, but the structure has worked out well. For example, the proportion of domestic and foreign applications has been maintained at 2 to 1, some 7,660 domestic patent applications having been received as compared with 3,949 foreign patent applications.

This shows that the Chinese patent laws have both been a stimulus to invention and creativity domestically, and have widely gained trust abroad. The proportion of invention patent applications to patent applications for new applications and designs have remained at about 2 to 1. The volume of invention patent applications has already reached 7,085, which shows that the number of patent applications are at a high level of inventiveness and creativity.

Huang Kunyi pointed out that among Chinese domestic patent applications, the proportion of vocational inventive creations to non-vocational inventive creations has largely stayed at 1 to 1, which shows that the Chinese patent laws have both encouraged enthusiasm for invention and creation among socialist enterprises and service units, and have also encouraged enthusiasm in the broad mass of workers to engage in invention and creation outside their work time. Regarding this latter situation, they have not been dependent upon research expenses from the state, but have been able to contribute a great deal of invention and creation to society, which is of benefit to the task of socialist modernization and progress in human civilization.

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GOALS OF NATIONAL S&T SURVEY DISCUSSED

Tianjin JISHU SHICHANG BAO in Chinese 12 Nov 85 p 1-2

[Unattributed article: "Song Jian, Chairman, National Science and Technology Commission Answers Reporters' Questions at National Training and Working Conference for Science and Technology"; first paragraph is source-supplied introduction]

[Text] Editor: The national training and working conference for the science and technology [S&T] survey was held from 5 November through the 14th in Tianjin. Song Jian [1345 0256], Deputy Director of the State Council Science and Technology leading group and chairman of the National Science and Technology Commission, attended the meeting and spoke there. During the period of the meeting, reporters from this newspaper put several questions related to the science and technology survey to Chairman Song Jian.

Question: What is the significance and goal of this survey?

Answer: At its 10th meeting, the State Council Science and Technology leading group decided that during the fall of this year and the spring of next, they would undertake a national science and technology survey, which is an extremely important and very urgent matter. Currently, the sixth 5-Year Plan to develop the national economy is just about to conclude, and the seventh 5-Year Plan is about to begin. At this critical moment, we want to allow restructuring of the science and technology system to develop deeply so as to better cater to economic construction, and to continue adjusting and stimulating scientific and technical capacities toward serving the chief goals of the national construction. We also want to allow them to carry out science and technology development plans in the seventh 5-Year Plan, and so must undertake a science and technology survey throughout the country. After the survey, we will gather the total data reflecting the condition of science and technology at the end of the sixth 5-Year period, as well as structural data, so that later, leadership organizations and research departments at every level can provide quantitative data for macroscopic control and analysis in the aspects of political, planning, and decision making. This will allow all areas of society to understand the whole picture of science and technology to better monitor and support the process of science and technology. In this survey, we will establish a sound system of scientific and technical statistical indexes, will cultivate and train science and technology

statistical workers, and provide a unified model and norm for gathering and storing data for base level statistical units. Through stratified handling, we will establish a statistics data bank network to quicken the pace of modernizing the statistics system. The results of this science and technology survey will aid in comparing our science and technology with various countries of the world and to draw from the experiences of developed nations, which will meet the needs of our open door policy and of the development of our science and technology; at the same time, for all levels of science and technology management departments and chief management personnel, it can improve the degree to which management can become scientific and also improve the standard of management.

Question: How are we to understand the importance of scientific and technical statistical work?

Answer: Speaking from the point of view of the whole country, science and technology is a complicated system, and if we use qualitative methods alone to analyze problems, there is already no way to meet the needs of development. If we are to allow the management of science and technology to get onto a scientific track, then we must pay attention to quantitative analysis. This is a developing trend in modern management, and it is information that management personnel must become aware of. In the past, people have always seen statistics as expendable, even to the extent of calling it an "above quota responsibility," which is incorrect. Lenin said, "Social statistics are one of the most powerful weapons for understanding society." Actually, statistics are the most important basis and means for scientific management. As the restructuring develops more deeply, science and technology management organs at all levels are going to be faced with paying close attention to macroscopic conditions, and with the duty of working out accurate policies. This is especially true for leading cadre, who must be freed from activities that excessively interfere with the autonomy of base level units, who must improve the standards of macroscopic management, who must allow the restructuring to be "lively without disorder" by chiefly focusing on the study of problems of a policy and directional nature, and who must support all this with a statistics system that has become better. Otherwise, we cannot formulate accurate policies and good strategies. If we rely only upon particular events to make our decisions, that would be quite twisted, for when making policy on the basis of "examples," sometimes we will suffer, even to the extent of losing time and opportunities.

For a long time now, the management of science and technology in China has lacked basic data that reflects the characteristics of scientific and technical activities, that is systematic, and scientific. What is the basic situation of our independent research and development organizations? After all, what kind of research and development capacity does each profession and enterprise have? How are we to adjust the deployment of scientific and technical capacities according to needs of the restructuring? How much of science research is put into production? Is the distribution of and structures for scientists and technicians rational? Only through scientific and technical statistics can we clarify these questions, and consequently provide a scientific basis by which all levels of management and decision making departments can formulate accurate science and technology policies.

Question: What are the primary objects and principles of this science and technology survey?

Answer: The primary objects of this science and technology survey are the 4,705 independent research and development organizations at the municipal, prefectural, and national levels, as well as some 5,000 medium to large enterprises. The scope and contents of the survey include: the state of independent research and development organizations, as well as the state of science and technology management organizations at the municipal, prefectural, or higher levels; the state of science and technology associations at all levels; the state of the transfer of rights to patents and technical achievements and the import-export technology trade. This survey demands "a clear concept, accurate data, and scientific methods." Seeing that this is the first time that we have set up a scientific and technical statistics system, there is a certain degree of the experimental to this survey, and it is a start by which China's science and technology statistics system will adapt to modern scientific management. This will be a survey of limited goals, limited time, and limited scope, and will use a limited amount of time to gather in a highly effective manner the data that is most urgent for formulating policy.

Question: What are the particular requirements of this science and technology survey?

Answer: Science and technology management departments at all levels, and especially the leading comrades, should be sufficiently respectful of statistical work. They should adopt strong measures to strengthen statistical work and get this work that is fundamental to management onto the right track. This will allow statistics systems to truly become responders and sensors under management control, and let them sensitively reflect true conditions and trends in the science and technology circles. With the aid of the State Statistical Bureau and the ministry commissions under the Central Committee, we will allow the science and technology statistics system to gradually come into line with the national statistics system and to fill in vacancies in China's science and technology system. Beginning right now, the science and technology management organizations at all levels will all offer specialist statistics services to provide to specialist staff statisticians. Scientific and technical statisticians must have strong sense of service, must have a broad scientific knowledge and training, and must strive to use scientific methods and modern statistical means to do this work well. Comrades participating in this training and working conference for the science and technology survey may be said to be the "foundation" of this effort, and are the "seed group" to develop a science and technology statistical system that is both suited to China's national situation and is also up to international standards. We want to develop creativity, and under conditions where time is short and the responsibilities heavy, to finish the science and technology survey, and open up a new aspect to China's science and technology statistics work.

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REPORT OF NATIONAL TECHNOLOGY MARKET SURVEY GROUP

Tianjin JISHU SHICHANG BAO in Chinese 5 Nov 85 p 1

[Unattributed article: "A Prosperous Technology Market Waits for Stronger Guidance"; first paragraph is source-supplied introduction]

[Text] Editor: Recently, the "Joint Survey Group for Policies and Rules and Regulations Related to the Technology Markets" sent out by the National Technology Market Coordinating and Guidance Small Group visited in turn the provinces and cities of Hunan, Guangdong, Shanghai, Xiangtan, Zhuzhou, Changsha, Guangzhou, Foshan, and Jiangmen, thoroughly investigating conditions for development in the technology markets and problems that have come up. What we have printed below is an abstract of their survey report.

I.

Since public announcement of the resolution by the CPC Central Committee regarding restructuring of the science and technology system, the commercialization of technical achievements and activities to open up technology markets have been rolling forward like waves in the ocean, and multi-level, multi-channel, and multi-format technology trade activities have been lively as never before.

Of the places visited by the survey group, what we saw first was technology trade and exchange organizations springing up like bamboo shoots after a spring rain, breaking through everywhere. According to incomplete statistics from the surveyed regions, there are more than 850 technology trading and consulting services of various sorts at the provincial level, 104 among which are in Changsha and 316 in Guangzhou, and at Shanghai's Jiaotong University alone there were more than 60 technology service companies. Various joint operations and joint groups, established using the format of technology shareholding, have sprung up as well. There are more than 460 of these in Hunan, more than 300 in Guangdong, and the Huadong Chemical Engineering Academy in Shanghai alone has 8 jointly operated plants and 20 joint groups.

Technology development service organizations from different systems in many places have already formed networks, each a front army with real strength, "each showing its special prowess," and with new prospects for serving the

development of production. As for example, what is called the 8th Route Army in a Shanghai technology market: the Shanghai Science and Technology Development and Exchange Center and the Shanghai Industrial Fund, and the Haixing Technology Development Company, the Chinese Academy of Sciences Science and Technology Development Service Company, the Science Association's Consulting Service Center, the higher institutions' Science and Technology Service Center, the staff technology association, and the civilian technology development organizations.

Still other areas have used the strength of overseas Chinese and their families to start technical and economic discussions and trade activities in Hong Kong and outside of China. They have imported foreign funding and technology to solve problems in China regarding technology development and technology renewal. As for example, Foshan, situated in the delta of the Zhujiang, which held discussions in Hong Kong in April of this year regarding the importation of technology and economic cooperation. They signed contracts and letters of intent with overseas Chinese and foreign commercial interests in amounts totaling more than 500 million US dollars. In Hong Kong, the city of Jiangmen held similar discussions and trade fair, at which they imported 106 technologies, for a total of $310 million.

II.

The survey group also saw that after technology markets had been opened, this accelerated the development and prosperity of urban and rural economies, and also brought life and vitality to research groups and colleges and universities. Technology markets have already become bridges and links from science and technology to the economy.

The Changsha Municipal Science and Technology Development Center caters to small to medium enterprises and town and township enterprises, is actively developing technical troubleshooting and technical consulting, and organized four professors to take charge of technique problem solving regarding the nationally famous Liuyang fireworks luminophor aluminum magnesium alloy. In only half a year's time, they made fireworks into the largest producing industry in Liuyang County, with an annual production value of $140 million. The Xiangtan Science and Technology Consulting Service Center with only four workers, organized more than 500 technicians into consulting for more than 153 projects both in and outside of the province, and in doing so saved three factories. They renewed the Zhaotan Chemical Plant from a situation of yearly losses for the 10 years of its existence, where it was about to fold, to a chemical plant with an annual production of 500 tons of barium nitrate, the product of which was in the international market in less than 1 year earning 500,000 yuan a year. The Shanghai higher level institutions Science and Technology Service Center organized the Huadong Chemical Engineering Academy to consult for the Baogang diversion project construction program, and when they changed from diverting water from the Dianshan Hu to getting it from the Changjiang, it saved the state 20 million yuan.

Opening up technology markets has allowed research units and colleges and universities to obtain better economic results. Based on statistics for 45 higher level institutions in Shanghai, in 1982 those schools had an income

from technology of 7 million yuan, which in 1983 was 19 million, in 1984 was 30 million, and in the first half of 1985 had reached 36 million, which was from 30 to 40 percent of their operating expenses.

Many research units have used the technology markets to feel out the needs for technology by production units, and have consequently found research topics in the needs of society. The Guangzhou Pharmaceutical Industry Institute did not not make any deals at the National Technology Exchange and Trade Fair, but then later, after understanding the needs of the buyers, some took out technical achievements that had a market and as independent companies held technology trade fairs, making 72 deals with a total trade value of 1.8 million yuan.

What was especially encouraging to people was that the process by which scientific and technical achievements were transformed into actual production forces quickened as the technology markets opened up. The dissemination rate for scientific and technical achievements in Hubei Province improved from the 20 percent of 1980 to 60 percent in 1984. The 49.6 percent in Hunan Province improved to 59.3 percent in 1984. The application rate for scientific and technical achievements in Changsha for 1984 was 85 percent, and 60 percent were appraised for the transfer of the application rights in the same year; research achievements by independent institutes in Guangzhou in 1984 went into production applications at a 76 percent rate, which was an improvement of 6.4 percent over the year before. Before technology markets had formed in Shanghai, the rate for transfer of achievement rights was only 20-30 percent, while among the 1,585 scientific and technical achievements in the 1984 economics commission system, the rights to 834 were transferred to production units, which is 52.6 percent.

III.

The current technology markets may be called a pleasant prospect, but some problems can still be seen, which are concentrated in the fact that policy guidance and macroscopic management cannot keep up with the developing situation.

First of all, a great number of different types of technology development organizations do not have centralized approval, monitored guidance, and management coordination; holding various technology exchange and trade fairs by names of all sorts, while no department can give accurate figures, nor anything about the talk and trade situation, nor technology channeling; this results in the technology markets in some locations giving rise to new fragmentation. Therefore, the survey group recommends that each area focus on the entity and establish corresponding technology market structures for organization, coordination, and management to attract the participation of the departments of science and technology, economics, finance, tax revenue, banking, industrial commerce, judicial, education, and statistics. These unified coordination and management structures would assume the following responsibilities: formulate policies and rules and regulations for technology markets, enhancing the macroscopic guidance of the technology markets; get information through; coordinate the work; undertake organization related to the technology markets, as for example registration, approval, statistics, and management of techonology trade contracts and arbitration.

Then, there is the problem of distribution of the income from transfer of the rights to technology. Currently, distribution of income from transfer of the rights to technology goes through many doors, the standards for different departments vary, and it is not done according to the nature of service, but rather is divided according to the department system, which creates conflicts within departments and systems. The survey group feels that distribution of the income from transfer of rights to technology should be strictly according to the principle of "division according to the amount of labor." It is recommended that unified methods be worked out that will avoid different departments and systems doing things their own way.

Third, many scientific research units and people who work in the technology markets are very concerned about taxes on transferred rights to technical achievements. We feel that income from the transfer of rights to technology ought to include transfer of rights to achievements, technical consulting services, technical training of talent, as well as any other technical income from assumption of a project other than hardware. These technical incomes would be exempt from taxes in the near term, based on the spirit of the "Resolution by the CPC Central Committee Regarding Restructuring of the Science and Technology System." That is to say that all activities having to do with the production of intellectual commodities and the circulation and exchange of technology should be exempt from taxation; all production and exchange or operation of material commodities ought to be taxed according to statutes (new products are exempt as provided for by relevant national provisions); all individual income will be taxed according to statutes for individual payment of taxes.

In the restructuring of the science and technology system, changing the funds allocation system and opening up the technology markets are two parts to one problem, they exist together, and are cause and effect of each other. Therefore, the survey committee believes that the tax revenue system ought to be appropriately adjusted, and for those research units that are actively undertaking reform, are changing their allocation system, and that do not need service fees, there should be an exemption from or reduction in taxation for encouragement.

In summary, the new problems discussed above await new surveys and study and the joining of each relevant department to propose methods for solution, and to allow continued perfection and development of the technology markets.

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NATIONAL DEVELOPMENTS

RESULTS OF ONE SICHUAN S&T TRADE FAIR DESCRIBED

Chengdu SICHUAN RIBAO in Chinese 6 Nov 85 p 1

[Text] It appears on the screen of a computer responsible for this province's fall technology achievements trade fair: in 4 days time, the number of transactions for the whole fair has already reached 2,125, and the volume of trade had broken through the 200 million yuan mark.

For 8 days now, the trade fair had been uncommonly active and business was prospering. Sellers were not giving up their efforts, and one after the other come up to give their pitch; buyers were considering long and hard, carefully considering the offerings. There were unexpected projects among the transactions, which yielded results that were pleasant surprises. Staff at the provincial and prefectural mining bureaus discovered strontium bearing reddish black ore of high grade and in large reserves, which, because of a lack of communication went unsold. Chemical engineering plants in Linshui and Pengshan counties had prepared as long ago as 1978 to take up strontianite production, but there were no ore resources. At this trade fair, both sides put their heads together and the difficulties were resolved.

Among projects transacted, some generated foreign currency and others saved on it. Military project plant No 570 had to buy screwtap dies from Hong Kong every year. At this trade fair, they discovered that plant No 7102 of the Ministry of Astronautics could manufacture them and at a price less expensive than imported. Right away, they signed a contract with that plant for 800 sets of screwtap dies. This was both convenient for production and also saved a great deal of foreign exchange.

Leadership of town and township enterprises from the top on down paid very close attention to this trade fair, organizing some 10,000 people to attend. In 4 days time, they had made deals for 263 projects, for a total of 30 million yuan, which was one-eighth of the total amount for transactions.

Trade by Office of Nationalities was also active. Transactions in 8 days totaled 14 million yuan, there were 20 projects for imported technology and one for bringing in talent. They warmly welcomed people from all areas to make plans to develop the nationality regions.

12586
CSO: 4008/2031

NATIONAL DEVELOPMENTS

PROVINCIAL SCIENCE COMMISSION SUCCESSES DESCRIBED

Chengdu SICHUAN RIBAO in Chinese 13 Nov 85 p 1

[Article by Tian Majiang [3944 7456 3068]: "Implement an Open Door Policy, Accelerate Science and Technology Development"]

[Text] Our provincial science and technology department actively develops international scholastic exchange, which has achieved outstanding results.

For more than 4 years, the provincial science and technology department has entertained more than 1,400 people who have come from more than 300 companies, enterprises, scientific research units, and as officials from more than 70 nations and regions. In addition, it has signed science and technology exchange and cooperation agreements with more than 20 foreign units. There have been more than 40 occasions where foreign specialists and scholars and leaders from companies and enterprises, invited by the Sichuan Province Science and Technology Exchange Center, have come to Sichuan for various technology exchange conferences, technical discussions, and technical exhibitions. They have developed wide-ranging technical exchanges, have obtained large amounts of foreign scientific and technical information, have imported more than 200 samples of the newest foreign products for our province, and through the borrowing of experiences and trial productions, these things have accelerated the renewal and updating of certain products of our province and the development of new products. After the electronic mosquito eliminator imported by an instrument calibration plant in the Xicheng district of Chengdu was improved, it was better than the foreign model. Then, after resale in more than 10 countries and regions in Asia, Africa, and Europe, annual output value reached 360,000 yuan. In 1981 and 1982, after this province invited some Japanese companies to undertake technology exchange regarding the development of (TIAN YE JU) and refining (TIAN YE JU) glucoside, some departments in the provincial Office of Agriculture and Animal Husbandry in cooperation imported (TIAN YE JU) seeds to develop within the province. The Chengdu Chemical Reagent Plant successively refined (TIAN YE JU) glucoside in complete accordance with standards, the sweetness of which is 250 times that of sugar. The results of this imported technology earned the Sichuan Provincial Prize for Major Scientific and Technical Achievements, and was ranked as a new technology for emphasis in dissemination throughout the province. This kind of (TIAN YE JU) glucoside is already being sold abroad, and is earning foreign exchange for the state. In 1983, since the provincial

science commission arranged for biomedical engineering artificial heart valve membrane specialists from this province to go to the United States for a visit, they have gradually mastered the advanced technology to manufacture artificial heart valve membranes. After a year of experimentation, a bovine heart with artificial valve membranes has been developed to international standards, results from clinical use have been excellent, and many units that have depended upon importing the product have placed orders.

The provincial science commission has also brought in some foreign talent in a planned, gradual way, that has been helpful in solving some key technical problems.

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CSO: 4008/2031

NATIONAL DEVELOPMENTS

SHANGHAI ECONOMIC METHODS WITH FOREIGN INVESTMENT

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 1 Nov 85 p 3

[Article by Shen Shiwei [3088 0013 0251] and Xia Ruge [1115 0320 7041]: "Shanghai Has Been Methodical in Using Foreign Funding and Importing Technology"]

[Text] Shanghai, 30 Oct, Xinhua--Shanghai Municipality has paid close attention to the management of utilizing foreign investments and importing technology, and has taken the first steps toward finding a fitting management system and methods that suit the new situation of opening to the outside.

Since Shanghai Municipality opened to the outside, it has made full use of its own economic, technical, and foreign trade advantages to actively make use of foreign investment and to import technology. Currently, the total amount of foreign funding that Shanghai Municipality has already attracted exceeds $1 billion, and 135 Chinese-foreign cooperatively funded, cooperatively run and independently foreign funded projects have been approved. There have been more than 800 instances of importation of foreign advanced technology and equipment, nearly 200 of which have gone into production for a new gain in annual output value of nearly 600 million yuan.

To suit this new situation of opening to the outside, and to reduce errors and losses as much as possible, the Shanghai Municipal Government has worked diligently at macroscopic guidance to achieve both an opening to the outside and management thereof. Their methods have been:

To Establish Comprehensive Coordinating Structures and Management Networks for Utilizing Foreign Investment and Importing Technology

There are two deputy mayors in the municipal government with the responsibility for attracting foreign funding and importing technology, respectively; also, with a deputy mayor as head, they have established a technology importation leading group composed of the planning commission, the economic commission, the commission on foreign trade, and the science and technology commission. This group supervises, inspects, coordinates, and arbitrates through a combined working conference. At the same time, a responsibility system is built hierarchically for each importation or cooperative project. From relevant commissions, offices, and bureaus to the factories themselves, responsibilities are established vertically for project

chief, project director, and project factory director, such that there are specialists responsible from top to bottom. Laterally, there is a project observation line based on a financial controller and a bank credit officer to serve the bank's functions in management and supervision, and consequently to allow the whole process of importation form a management network with contacts both vertical and horizontal.

To Enhance the Macroscopic Management of Import Projects

To improve importation efficiency, the municipal government has provided that technology importation projects under $2 million and joint-run projects having a total investment under $5 million can be approved by each responsible office. At the same time that it laid out limits of approval authority, the municipal government worked out overall plans for the city to open to the outside, they pointed out technical transformations of older enterprises that should be considered in attracting foreign investment and in the importation of technology, the overall functions to be attended to in using and enhancing central cities, and demanded that each profession aim for the levels of advancement of similar foreign professions, that it import advanced technology in a planned and focussed way, and that it stimulate the technical advancement of the entire profession. The municipal government also organized industrial, foreign trade, and financial departments, and formulated technical transformation programs for 100 professions on the basis of gaps between several hundred major commodities and their foreign equivalents as surveyed and analyzed. They also determined that 22 professions, such as instrumentation, electronics, knitting, weaving machinery, plastics, and metallurgy, would be the focus of technical transformation.

To Make a Good Overall Balance, to Channel Funds into Projects That Are Knowledge Intensive, Technology Intensive, and That Create Foreign Currency Through Export

Through an analysis of trends in foreign funding and in technical development, the municipal government and relevant departments have made 33 categories of projects among the 22 emphasized professions, concerning engineering plastics, electronics technology, precision machinery, household appliances, photographic equipment, food processing, and post-weaving handling, as the principal directions for funding for import and cooperation. Currently, the majority among the 135 projects of cooperation between Shanghai Municipality and foreign commercial interests are knowledge intensive, technology intensive, and generate foreign currency through export.

To Amplify Rules and Regulations Regarding Foreign Economies

Based on the laws and regulations formulated by the state regarding opening to the outside, and to integrate with the actual situation in this city, Shanghai Municipality has in recent years formulated a group of local rules and regulations regarding foreign economies. Each unit making use of foreign funding and importing technology will, when negotiating and signing agreements and contracts, engage the office of accountants and the office of economic rules for foreign nationals as advisors and witnesses, as well as to write up their opinions on the approval documents.

To Maintain the Opening to the Outside, Enhance Management, and Allow the Use of Foreign Funding and Importation of Technology by Shanghai Municipality to Achieve Remarkable Results

Through the importation and absorption of foreign advanced technology, a group of enterprises, such as foodstuffs, knitting, electronics, textile machinery, plastics, and metallurgy, the original equipment of which was obsolete and the technology of which was behind the times, have been refitted with new technology, and the products of certain industries have gotten rid of their "old look" to gain competitive ability in the international market.

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CSO: 4008/2026

NATIONAL DEVELOPMENTS

SERVING THE LOCAL ECONOMY WITH SCIENCE, TECHNOLOGY

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 10 Nov 85 p 4

[Text] How is the scientific and research of higher level institutions going to serve the promotion of local economies? It is the belief at Qinghua University they they should actively be the "first and second links" in the transmission of advanced, dependable "short, even, fast" technology to medium and small enterprises and town and village enterprises. They have been achieving preliminary results for a year now.

According to a report in GUANGMING RIBAO, what is meant here by "first link" is that, from the point of view of the higher level institutions, based on the needs for technology of the town and village enterprises and during the process of completing the national comprehensive scientific research projects given them by the nation, they will intentionally break down a portion of small scale, specialized, modern, and highly effective technology projects into research topics for "short, even, fast" technologies, and will specifically organize their efforts into promoting research and development; the so called "second link" is to promote "short, even, fast" technical achievements by various methods, to allow them to be applied by small and medium enterprises and town and village enterprises as quickly as possible.

To be a good "first link," at the same time that Qinghua University completes its teaching obligation and national major research topics and basic research, it will methodically organize teachers into practical technology exchange activities of various types and forms. This will provide a basis for determining research topics in "short, even, fast" technologies. Because high rise buildings are getting more common and there has been an increase in demand for high quality heating plates, teachers in the department of mechanics broke down a rare earth and cast iron heating plate technology while studying the overall topic of "metallurgical characteristics" and achieved results after repeated experiments that allowed the working pressure of hot water heating plates to be doubled, which is very suitable for installation in high rise buildings.

Teachers at Qinghua University have also actively developed the function of the "second link," transmitting advanced, dependable new technology as quickly as possible to small and medium enterprises and town and village enterprises. The department of chemical engineering has used computer-aided design to

develop a replacement for a key technology in small chemical fertilizer plants--a new type of furnace comb for a synthetic ammonia gassifier, which resolves a technical difficulty in which gassifiers easily created sediment. This achievement has been promoted in several provincial cities in Hebei, Henan, and Hubei, and many small chemical fertilizer factories have used this new device in just a short time. This has caused a 10 percent improvement in single furnace output, a 10 percent reduction in raw materials, and average yearly economic results for a single furnace of over 100,000 yuan.

12586
CSO: 4008/2026

NATIONAL DEVELOPMENTS

CAS EXPANDS EXCHANGES

OW281706 Beijing XINHUA in English 1504 GMT 28 Jan 86

[Text] Beijing, 28 Jan (XINHUA) -- Officials of the Chinese Academy of Sciences [CAS] said today they sponsored 6,000 scholarly exchange visits last year, up from 2,700 in 1980.

The academy has established ties with 50 countries and regions and signed 43 cooperative agreements, they said.

Since 1978, aside from sending its scientists to academic meetings abroad, the academy has sent more than 5,300 scientists to some 30 countries for advanced study or cooperative research in such fields as physics, chemistry, microelectronics, information technology, materials science, bio-engineering, lasers, remote-sensing technology and marine engineering.

In addition, CAS sponsored more than 40 international symposiums in China in the past five years on such topics as science policy, mountain meteorology and polymer materials.

Last August, CAS opened two of its 120 institutes to foreigners and 17 other institutes have opened at least one of their laboratories, at which 32 foreign scientists work jointly with their Chinese colleagues on 24 subjects.

At the same time, several institutes have established joint laboratories with foreign organizations for developing new technology and products, the officials said.

In one case, the Shanghai Institute of Cells cooperated in the field of biology with three scientific institutions from the Federal Republic of Germany.

Also, the Shanghai Institute of Medicine and the Kunming Institute of Botany are developing anti-tumor herbal medicine together with a Japanese company. Chinese and British scientists last summer conducted a joint survey of the Qinghai-Tibet plateau.

/12929
CSO: 4010/2007

NATIONAL DEVELOPMENTS

CAS SURVEY SHIP RETURNS FROM WESTERN PACIFIC

OW281953 Beijing XINHUA in English 1917 GMT 28 Jan 86

[Text] Guangzhou, 28 January (XINHUA) -- A scientific survey ship, the "Shiyan 3", of the Chinese Academy of Sciences [CAS] returned here today after completing a 7-week survey mission in the western Pacific.

During its 13,000 km voyage, the ship made observations of the ocean and the atmosphere ranging from 4,000 meters in the water to 16,000 meters above the sea level.

It is determined that the temperature of the water 4,035 meters deep in the western Pacific east of the Philippines and north of Indonesia, is 15 degrees centigrade, and the temperature at an altitude of 16,000 meters is 85 degrees below zero centigrade.

Data on five layers of the sea current were acquired by placing a buoy for 60 hours at an observation station 3,058 meters in the water along the equator.

In an equatorial sea area, a profile on key meterological elements over 1,000 meters above the sea was taken. In the same area, Chinese scientists aboard the ship discovered that there is no connection between the daily change of water vapour and the day length.

They also discovered that there is no obvious daily change in the interactions between the ocean and the atmosphere in a tropical sea area in winter.

The ship came across a force six northwest wind in an area of the equatorial calms, which testifies that the area under survey is an important passage for atmospheric circulation between the south and north hemispheres. Through their 72-hour observation, scientists acquired basic parameters on interactions between the ocean and the boundary layer of the atmosphere.

These achievements have helped the Chinese scientists obtain a better understanding of the interactions between the sea and the atmosphere.

This survey is part of a key research project to study the interactions between the sea and the atmosphere and the yearly weather changes in tropical areas in the western Pacific.

The project is scheduled to last ten years. Winter and summer surveys will be carried out in [word indistinct] every of the first four years.

The next survey will be conducted in October.

NATIONAL DEVELOPMENTS

ENGINEERING COLLEGES SERVE ECONOMY THROUGH S & T COOPERATION

OW011146 Beijing XINHUA in English 1127 GMT 1 Feb 86

[Text] Beijing, 1 February (XINHUA) -- Almost all China's colleges of engineering have established cooperative contacts with enterprises and businesses in the science and technology fields, and 70 percent to 90 percent of the research results achieved by universities and colleges have been transferred to economic departments.

According to statistics of the state education commission, more than 300 associations for teaching, scientific research and production have been set up by 30 key universities and colleges with enterprises, and these universities have also signed 800 contracts for long-term cooperation and 7,000 ones for short-term cooperation with enterprises.

Of all the technological items these universities transferred to enterprises, more than 150 have brought in annual revenues of one million yuan each, totalling 810 million yuan a year.

The statistics of 85 colleges show that they have helped economic departments train 350,000 people in the past few years.

Professors and associate professors make up 50 percent of the country's total specialists and other senior technical and scientific personnel, and China has 1,000 universities and colleges.

Since May 1982, when Premier Zhao Ziyang suggested establishment of associations for teaching, scientific research and production in universities, scientific and technological cooperation and technical transfer have gradually become the main and the most effective measures for universities and colleges to serve the national economy.

Many institutes of higher learning offer technical aid and training courses to factories and plants where technicians are lacking. In Sichuan Province 15 colleges cooperated with 400 small and medium-sized enterprises, and 300 of them which had suffered losses now make profits.

In academic areas, universities and colleges have become important scientific and technical bases.

The Tianjin Municipal Industrial Department has established a dozen associations with institutes of higher learning; while Shanghai started its cooperation with universities in 1983 by setting up research institutions at universities.

Many universities have entered into long-term cooperative research on sophisticated technology. A development and research center for petroleum and natural gas, and an institution for chemical reaction engineering have bene set up by the Ministry of Petroleum Industry and Nanjing University, and by the China Petrochemical Corporation, Zhejiang University and the Huadong Institute of Chemical Industry, respectively.

To promote technical transfer, many universities and colleges have also set up corporations doing business in technical items at home and abroad. In Shanghai there are 130 such corporations.

Officials from the State Education Commission said that technological cooperation with economic departments helps overcome the defect of separating education, scientific research and economic development that exists in China's educational structure.

For many colleges of engineering, half the funds spent on scientific research come from scientific services to enterprises.

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CSO: 4010/2007

NATIONAL DEVELOPMENTS

PEASANTS ACQUIRE S & T FACTS THROUGH FILMS

OW281832 Beijing XINHUA in English 1646 GMT 28 Jan 86

[Text] Beijing, 28 January (XINHUA) -- It happened one night in Shandong Province. A movie theater in rural Sishui County was showing "The Tricks of Witch Doctors" -- and one was in the audience.

After the documentary was finished and the theater was no longer dark, the old man spoke to the crowd, many of whom had long believed him to be a wizard. This was last year.

"What the film shows is true," he said. "Give up your superstitions and I won't fool you again."

Two thousand km to the southwest, in Sichuan Province, the film attracted another large audience. The village was Hongguang, in Anxian County, where earlier in the year 41 people who could not swim drowned after a local wizard had told them to jump into a pond. Said a local film distributor, "If only the film had been shown earlier..."

In China, where only one out of five people has access to a television set, film remains a central medium of mass communication. And sometimes what the information films convey -- particularly science and educational films -- can change people's lives. Nearly 1,300 copies of "the tricks of witch doctors" have been sold.

Nearly half of China's science and educational films are made by the Beijing Science and Educational Film Studio, which produced 53 last year, the most in its 25-year history.

Zhang Qing, deputy director of the studio, said today the increased production "is in response to the rapid increase in demand."

"The need is particularly urgent in rural areas," she said, "for more and more peasants have come to realize that they can learn from films how to develop agriculture in a scientific way."

"And since many peasants are still illiterate, showing them films can offer a shortcut to teaching them science and technology."

For example, she said, peasants in many districts have learned how to make their drinking water sanitary from the film "Simply-built System of Running Water in the Countryside," and "Pig Raising Technology" has encouraged peasants throughout China to raise pigs with leaner meat.

Other film studios also make science and educational films, including the Beijing-based China agricultural film studio. Among their productions have been films about agricultural and industrial production, enterprise management, education, medicine, science and technology, and health and other practical information useful in everyday life.

Viewers in China's provinces have been promoting the films on their own, particularly in rural areas, Zhang said. In Sichuan Province's Nanchong Prefecture, for example, they have established an association to popularize the films, and in Henan Province's Xinyang Prefecture, they have planned a science and educational film week for the spring.

"These and other examples of viewer support encourage us," said Zhang.

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CSO: 4010/2001

NATIONAL DEVELOPMENTS

NEI MONGGOL BOASTS MAJOR ELECTRONICS INDUSTRY

OW310810 Beijing XINHUA in English 0724 GMT 31 Jan 86

[Text] Hohhot, 31 Jan (XINHUA)--Inner Mongolia Autonomous Region, famed for its grasslands, is now boasting a major electronics industry.

A regional industry official said Inner Mongolia now had 35 electronics businesses making 70 types of products, including radios, tv sets, computers, telecommunications equipment, electronic machinery and domestic appliances.

Output value from this sector last year amounted to 190 million yuan up 100 million yuan over 1984.

Last year, the region produced 175,000 tv sets, 13 times more than in 1980, 504 computer hardware systems, 2.6 times more, and 4,200 electronic surveying instruments, 2.3 times more.

The INNER MONGOLIA DAILY newspaper reported that for every 100 urban families in the region there were at the end of last year 61 black-and-white tv sets, 52 washing machines, 37 cassette recorders, 21 color tvs and 5 electric fans.

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CSO: 4010/1029

NATIONAL DEVELOPMENTS

BRIEFS

LIAONING SCIENTIFIC RESEARCH--During the implementation period of the Sixth 5-Year Plan, Liaoning Province scored a large number of results in scientific and technological research with high technical standards and marked economic returns. The number of these results has reached 9,090 items. Of these items, 3,690 results have very important targets, 7 results have been commended by the national authorities, 56 results have been awarded with prizes of invention, 64 results have been awarded with the prizes of progress, and 1,910 results have been commended by the provincial people's government. In the last 3 years of the 5-year period, more than 3,200 scientific and technological results have been popularized and applied, which create more than 2.23 billion yuan in industrial output value each year and more than 440 million yuan of profits and taxes. [Excerpts] [Shenyang Liaoning Provincial Service in Mandarin 1030 GMT 27 Jan 86 SK] /12232

CSO: 4008/2059

JPRS-CST-86-008
1 March 1986

PHYSICAL SCIENCES

INSTABILITY IN LOWER IONOSPHERE AT LOW LATITUDE

Wuhan WUHAN DAXUE XUEBAO (ZIRAN KEXUE BAN) [JOURNAL OF WUHAN UNIVERSITY (NATURAL SCIENCES EDITION)] in Chinese No 2 [Jun] 84 pp 39-44

[Article by Liu Xuanmou [0491 6693 6180], Liu Cenghou [0491 2582 0624], Gu Tao [7357 3447] and Cui Rong [1508 2837]

[Text] Abstract: In the lower ionosphere, a DC electric field is induced by the collision between charged and neutral particles. In addition, there is a vertical electron density gradient due to the presence of the Hall current induced by the earth magnetic field and the partially ionized plasma in the ionosphere. Under these conditions, their combined effects will cause instabilities in this region. Based on the two-fluid plasma equation, the growth rate γ of these instabilities is derived in this paper. Numerical simulation of this instability shows some fluctuation in electron density in the lower ionosphere 150 seconds after the disturbance. The spatial scale of the undulation is of the order of several hundred meters to several kilometers. In addition, it has a tendency to move in the vertical and horizontal directions. Furthermore, the observation made during the solar eclipse in Yunnan of 16 February 1980 is also discussed.

In the early 1960's, Bowles[1] et al observed that the equatorial electrojet in the lower ionosphere had inhomogeneities of the order of several meters by using incoherent scattering. In order to explain this phenomenon, Farley[2] et al immediately presented the plasma instability theory. Recently, because of the undesirable effect of Spread-F on satellite to ground transmission, Booker[3]-[6] et al described Spread-F theoretically, as well as experimentally. It is generally believed to be the CR-T instability created in the F region in the equatorial ionosphere. Ossakow[7] and Zallesak[8] conducted a serious of numerical simulations of the CR-T instability in the F region at the equator in the night. The "bubble" theory of the non-linear equatorial Spread-F was introduced. These efforts are limited in the highly ionized F region. The observation made during the solar eclipse in Yunnan on 16 February 1980[9] shows that there are also inhomogeneous bodies of various sizes in the lower ionosphere. We believe that this may be related to the static electric field created due to the disappearance of the ionization source in the lower ionosphere in the band of the solar eclipse. This instability is the result of the combined effect of the Hall current induced by the non-linear polarization EXB, the drift gXB

caused by the gravitational field and the electron density gradient in the lower ionosphere. In the lower ionosphere, the collision frequencies between an electron and a neutral particle and an ion and a neutral particle, ν_{en} and ν_{in}, are related to the spin frequencies of electron and ion, Ω_e and Ω_i, as $\frac{\nu_{en}}{\Omega e} \ll 1$ and $\frac{\nu_{in}}{\Omega i} \approx 1$ (or >1), respectively, Under these conditions, we derived that the growth rate of the instability, γ is related to factors such as the gravitational force per unit mass g, the recombination coefficient α_R, the collision frequency ν_{in}, the background electron density gradient $(\partial N_o / \partial y)$, and the disturbance wave numbers k_x and k_y.

Theory

The geometrical pattern of the problem under discussion is similar to that used by Ossakow. Instead of the F region, the region involved is the lower ionosphere. The coordinate is chosen as follows: assuming the earth magnetic field is constant and points in the direction of the z-axis (north), the gravity g is in the negative y direction, the x-axis is pointing west, and it is limited to the region near the equator as shown in Figure 1. The continuity and matrix

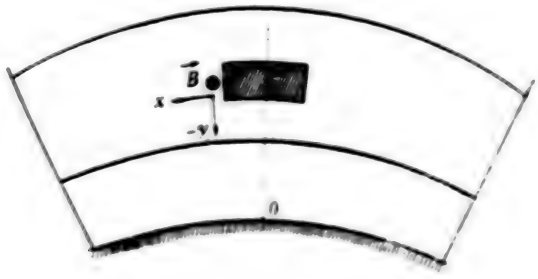

Figure 1. Geometry of the Equatorial Lower Ionosphere

equations describing this two-dimensions (x,y) two-fluid plasma system are:

$$\frac{\partial N_\alpha}{\partial t} + \nabla \cdot (N_\alpha \boldsymbol{V}_\alpha) = \alpha_R (N_{\alpha o}^2 - N_\alpha^2) \qquad (1)$$

$$N_\alpha m_\alpha \frac{\partial \boldsymbol{V}_\alpha}{\partial t} = N_\alpha q_\alpha (\boldsymbol{E} + \boldsymbol{V}_\alpha \times \boldsymbol{B}) + N_\alpha m_\alpha \boldsymbol{g} - N_\alpha m_\alpha \nu_{\alpha n} \boldsymbol{V}_\alpha \qquad (2)$$

Here, the subscript α represents the type of particle (e for electron, i for ion and n for neutral particle). The recombination process

in the lower ionosphere is proportional to the square of electron density, which is different from that in the F region. $\alpha_B N_{e_0}^2$ represents an ionization source in the lower ionosphere and $\alpha_B N_e^2$ represents the loss caused by recombination. If we assume that the inertia time (such as the relaxation time of the recombination process in the lower ionosphere caused by a solar eclipse) is larger than the spinning cycle and mean time between collision of charged particles, we can then neglect the inertia term on the left of eq(2). Eq(2) can then be changed to an algebraic equation to solve for $\sqrt{\alpha}$. In addition, the electronic and ionic velocities are found to be

$$\boldsymbol{V}_e = \left(\frac{\boldsymbol{E}}{B} + \frac{\boldsymbol{g}}{\Omega_e}\right) \times \hat{B} + \frac{\nu_{e_0}}{\Omega_e}\left(\frac{\boldsymbol{E}}{B} + \frac{\boldsymbol{g}}{\Omega_e}\right) \qquad (3)$$

$$\boldsymbol{V}_i = P_i\left[\left(\frac{\boldsymbol{E}}{B} + \frac{\boldsymbol{g}}{\Omega_i}\right) \times \hat{B} + Q_i\left(\frac{\boldsymbol{E}}{B} + \frac{\boldsymbol{g}}{\Omega_i}\right)\right] \qquad (4)$$

Here

$$\hat{B} = \boldsymbol{B}/|\boldsymbol{B}| \qquad \Omega_e = eB/m_e$$

$$P_i = \Omega_i^2/(\Omega_i^2 + \nu_{i_0}^2) \qquad Q_i = \nu_{i_0}/\Omega_i$$

By using the static approximation $\boldsymbol{E} = -\nabla\phi$ and the quasineutral condition $N_e \approx N_i \approx N$, we get

$$\nabla \cdot \boldsymbol{J} = 0 \qquad (5)$$

$$\boldsymbol{J} = Ne(\boldsymbol{V}_i - \boldsymbol{V}_e) \qquad (6)$$

By substituting eqs (3) and (4) into (6) and calculating Eq(5), we get

$$\frac{\partial\phi}{\partial y}\left(\frac{\partial P}{\partial x} - \frac{\partial R}{\partial y}\right) - \frac{\partial\phi}{\partial x}\left(\frac{\partial P}{\partial y} + \frac{\partial R}{\partial x}\right) - R\nabla^2\phi - g\left(\frac{\partial Q}{\partial x} + \frac{\partial S}{\partial y}\right) = 0 \qquad (7)$$

By plugging the velocity $V_{\times}$ into the continuity equation (1), we have

$$\frac{\partial N}{\partial t} - \frac{P}{B}\left[(\nabla\phi \times \hat{B}) + Q_1\nabla\phi - \frac{m_i}{e}(\boldsymbol{g}\times\hat{B} + Q_1\boldsymbol{g})\right]\cdot\nabla N = \alpha_R(N_0^2 - N^2) \quad (8)$$

where

$$P = \frac{Ne}{B}\frac{\nu_{in}^2}{(\Omega_i^2+\nu_{in}^2)} \qquad Q = Ne\frac{\Omega_i}{(\Omega_i^2+\nu_{in}^2)}$$

$$R = \frac{Ne}{B}\frac{\Omega_i\nu_{in}}{(\Omega_i^2+\nu_{in}^2)} \qquad S = Ne\frac{\nu_{in}}{(\Omega_i^2+\nu_{in}^2)}$$

In reality, equation (8) represents the ionization equilibrium equation to be satisfied in the lower ionosphere due to the presence of Hall drift, gravity and cross-sectional gradient. Then, let $\phi = \phi_0 + \phi$, and substitute it into eqs (7) and (8). After linearizing these equations, the condition to be satisfied by the zeroth order potential in the ground state is

$$\nabla\phi_0 \times \hat{B} + Q_1\nabla\phi_0 = \frac{m_i}{e}(\boldsymbol{g}\times\boldsymbol{B} + Q_1\boldsymbol{g}) \quad (9)$$

From equations (3) and (4) we know that this condition makes the ground state satisfy

$$\left.\begin{aligned} \boldsymbol{V}_{i0} &= 0 \\ \boldsymbol{V}_{e0} &= \left(\frac{1}{\Omega_e} - \frac{1}{\Omega_i}\right)\boldsymbol{g}\times\boldsymbol{B} \\ \boldsymbol{J}_0 &= -N_0 e\boldsymbol{g}\times\boldsymbol{B}/\Omega_i \end{aligned}\right\} \quad (10)$$

It is obvious that the background velocity of an ion is zero because the mass of an ion m_i is much larger than that of an electron m_e. In addition, electrons move under the influence of the external magnetic field and gravitational field. Hence, J_0 is also primarily created by electronic motion. We can see that the ground state is stable. Because P, Q, R and S all contain N, therefore, they can be written as

$$P = P_0(N_0 + N_1),\ Q = Q_0(N_0 + N_1),\ R = R_0(N_0 + N_1),\ S = S_0(N_0 + N_1) \quad (11)$$

Moreover, the following is satisfied:

$$\frac{m_i}{e}P_0 = \frac{\nu_{in}^2}{\Omega_i^2}Q_0,\ \frac{m_i}{e}R_0 = S_0,\ \nabla\phi_0 = \frac{m_i}{e}\boldsymbol{g} \quad (12)$$

Furthermore, P_o, Q_o R_o and S_o remain unchanged with x. If we neglect the effect of higher order potential and other electric fields, the first order equations derived from eq (7) and (8) are

$$\frac{\partial\phi_0}{\partial y}\left[P_0\frac{\partial N_1}{\partial x}-\frac{\partial}{\partial y}(R_0N_1)\right]-\frac{\partial\phi_1}{\partial x}\frac{\partial}{\partial y}(P_0N_0)-\frac{\partial\phi_1}{\partial y}\frac{\partial}{\partial y}(R_0N_0)$$
$$-g\left[Q_0\frac{\partial N_1}{\partial x}+\frac{\partial}{\partial y}(S_0N_1)\right]-R_0N_0\nabla^2\phi_1=0 \qquad (13)$$

$$\frac{\partial N_1}{\partial t}-\frac{P_1}{B}(\nabla\phi_1\times\hat{B}+Q_1\nabla\phi_1)\cdot\nabla N_0=2\alpha_R N_0N_1 \qquad (14)$$

where ϕ_1 is the perturbation potential and $-\nabla\phi_1$ is the perturbation field. Equations (13) and (14) are the basic formulas to find the cross section N(y) on the (xy) plane.

In the lower ionosphere, the densities of electrons and ions are far less than that of neutral particles. Therefore, the collision between charged particles and neutral particles has an important effect on the kinetics. Because limited by such collisions, the drift caused by gravity separates different charged particles somewhat, which induces a DC electric field.

Under the influence of the earth magnetic field, it induces the Hall drift. In general, the tidal motion of the ionosphere is mostly in the east-west direction. The changes of the ionosphere at sunrise and sunset, as well as the perturbation induced by the disappearance of the ionization source in a solar eclipse, can produce a vertical component. The combined effect of these processes can lead to the growth of perturbation, resulting in the characteristic instability in the lower ionosphere. It is most prominent over the equator. In order to determine the growth rate of this instability, we assume that

$$\left.\begin{aligned}N_1&=N_{1e}^{j(k_xx+k_yy-\omega t)}\\ \phi_1&=\phi_{1e}^{j(k_xx+k_yy-\omega t)}\end{aligned}\right\} \qquad (15)$$

which is substituted into eq (13) and (14). In addition, we assume that N_0, ν_{in}, α_R are functions of the altitude and g, B, Ω_i do not vary with the altitude. After simplification, the angular frequency of the perturbation $\omega=\omega_r+j\gamma$ is a complex number.

$$\omega_r = P_1(k_x - Q_1 k_y)\frac{\partial N_e}{\partial y}\, g\, \frac{-k_x\left[k_y \frac{\partial}{\partial y}(P_1 N_e \nu_{in}) + k_x \frac{\partial}{\partial y}(P_1 Q_1 N_e \nu_{in})\right]}{\left[k_y \frac{\partial}{\partial y}(P_1 N_e \nu_{in}) + k_x \frac{\partial}{\partial y}(P_1 Q_1 N_e \nu_{in})\right]^2 + (P_1 N_e \nu_{in} k^2)^2} \tag{16}$$

$$\gamma = P_1^2(k_x - Q_1 k_y)\frac{\partial N_e}{\partial y}\, g\, \frac{N_e \nu_{in} k_x k^2}{\left[k_y \frac{\partial}{\partial y}(P_1 N_e \nu_{in}) + k_x \frac{\partial}{\partial y}(P_1 Q_1 N_e \nu_{in})\right]^2 + (P_1 N_e \nu_{in} k^2)^2} - 2N_e \alpha_R \tag{17}$$

Equation (17) is the growth rate of the instability induced by the perturbation in the lower ionosphere. It is clear that the growth rate is positive below the peak ionosphere $\left(\frac{\partial N_e}{\partial y} > 0\right)$, i.e., when the first term is positive and is larger than the second term. However, this condition is difficult to meet in the lower ionosphere. Only on the bottom of the ionosphere or when there is an E_S layer then $\left(\frac{\partial N_e}{\partial y}\right)$ is very large. Therefore, this type of instability may only be triggered in the lower ionosphere under the proper perturbation condition. In the upper ionosphere, however, $Q_1 \ll 1$. In this case P_1 approaches 1, and equation (17) becomes

$$\gamma = \frac{k_x^2 k^2 g \nu_{in} N_e (\partial N_e/\partial y)}{\left[k_y \frac{\partial}{\partial y}(N_e \nu_{in})\right]^2 + (N_e \nu_{in} k^2)^2} - 2N_e \alpha_R \tag{18}$$

With the exception of the recombination term, the result of this equation is the same as that given in reference [7]. This is the expression for the commonly discussed CR-T instability. In addition, we can see from equation (17) that the growth rate is very large when the perturbation is purely horizontal (ky=0). A perturbation purely in the vertical direction (k_x=0) cannot trigger this type of instability. On the other hand, when $Q_1 \gg 1$, it seems that this type of instability might be triggered in the "valley" region of the ionosphere where $\frac{\partial N_e}{\partial y} < 0$ if $Q_1 k_y > k_x = 0$ can be satisfied such as the case of strong vertical disturbance at sunrise and sunset.

Numerical Calculation and Discussion

The objective of this calculation is to determine changes of the electron density cross section in the lower ionosphere when disturbance exists. The starting point is equations (13) and (14), together with the corresponding boundary conditions. It is apparent that equation (13) is an elliptical equation and (14) is a hyperbolic equation. We used a combination of leap-frog and iteration to simultaneously solve this set of partial differential equations. The calculation was carried in two dimensions (x,y). In the process, we kept the terms

proportional to ν_{in}/Ω_i in equation (13) and neglected terms proportional to $1/\nu_{in}$. The range of simulation was 8 kilometers in the x direction (42 points at 200 meters apart) and 70 $\sim$ 120 km in the y direction (52 points at 1 km apart). The boundary condition of N_1 and ϕ_1 is periodic in the x direction. It belongs to the second category boundary condition in the y direction ($\partial N_1/\partial_y = 0$, $\partial\phi_1/\partial_y = 0$). The initial disturbance is the same as the disturbance B used by Zalesak, i.e.

$$\omega = -\frac{N(x,y,0)}{N_0(y)} = 1 - e^{-s}\cos\left(\frac{\pi x}{20\Delta x}\right) \qquad (19)$$

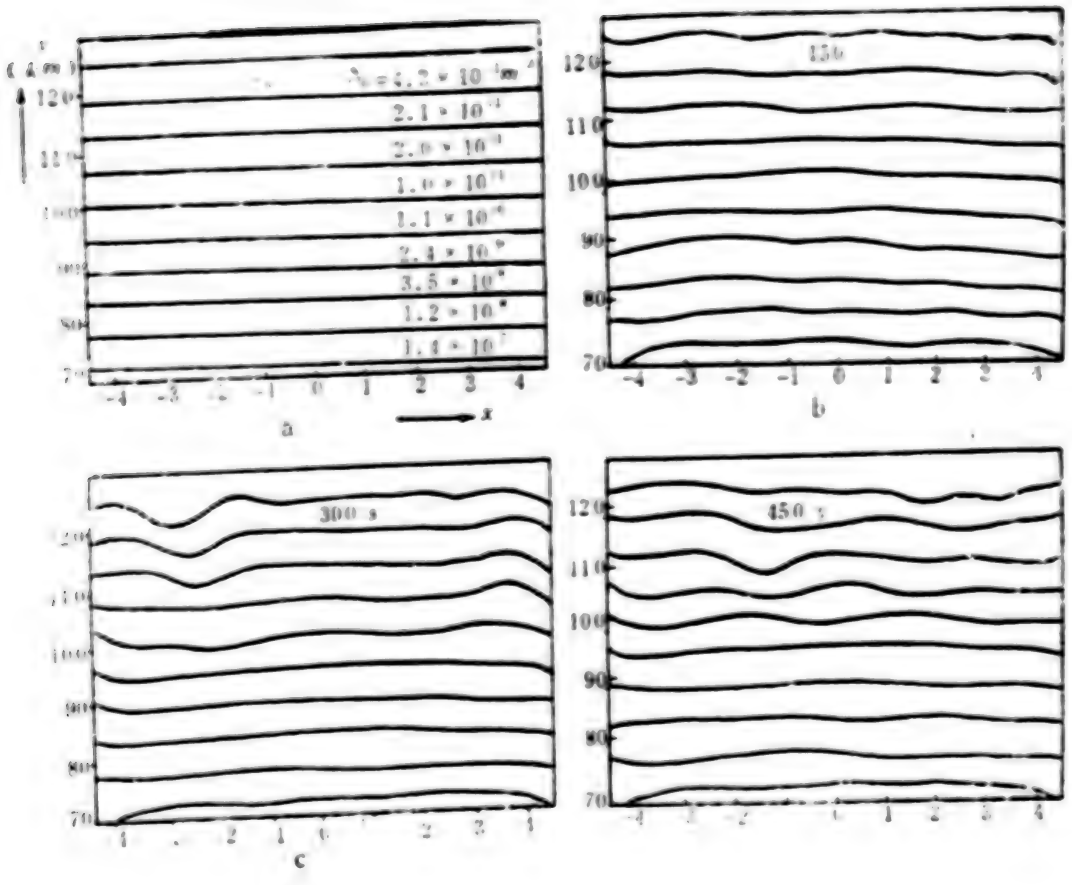

Figure 2. Iso-density Curves Obtained by Calculating N/N_o at t=0 sec (a), 150 sec (b), 300 sec (c) and 450 sec (d)

Results of our calculation show that in most cases the value of N/N_0 is not different from 1 by much. Figure 2 shows several calculated iso-electron density $N(y)/N(y_0)$ contours at different instances. We can see that initially (0 sec) the ionosphere is divided into uniform horizontal layers. The cross-section does not vary by much at 50 seconds after the disturbance. At 150 and 300 seconds, the cross-section apparently is no longer divided into uniform horizontal layers. In addition, the disturbance has a tendency to move in both vertical and horizontal directions. The scale of the disturbance is of the order of several hundred meters to several kilometers. We are unable to plot the result at 450 seconds because the data did not converge. Furthermore, the Ω_i chosen is on the high side which requires further calculation. Figure 3 shows the variation of the amplitude and its Doppler frequency shift of a high frequency signal (f=5.25 MHz) transmitted by the ionosphere during the solar eclipse in Yunnan on 16 February 1980. The figure shows that the scattered component of the high frequency signal increased significantly after the initial eclipse. Moreover, the Doppler record also indicates that the reflection surface had serious undulations. This shows that non-uniform ionization density bodies in various scales might be excited in the lower ionosphere because of the instability mentioned above. In this case, the ionization source disappeared and the electron density was reduced to create a horizontal static electric field. Charged particles in the high density region outside the eclipse band move toward the eclipse band to create horizontal disturbances. At this time, the Hall drift caused by the non-linear polarization ExB is in the vertical direction. Furthermore, at approximately 17:00 hours local time the apex angle of the sun increased rapidly. The cooling of the lower ionosphere also led to disturbances in the vertical direction. These disturbances might lead to the growth of such instabilities.

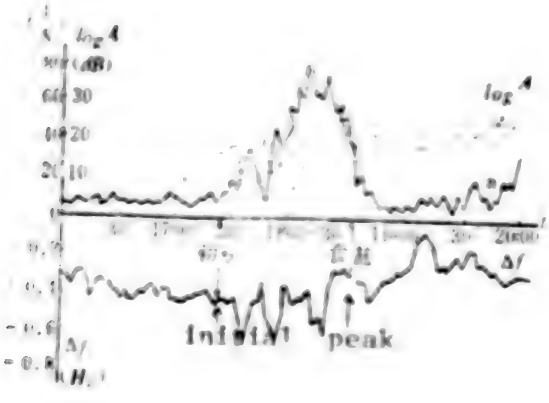

Figure 3. Variation of Amplitude Log A, Decay Rate n and Doppler Frequency Shift Δf of a High Frequency Signal Reflected by the Ionosphere With Time During the Solar Eclipse on 16 February 1980 in Yunnan

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PHYSICAL SCIENCES

CRYOGENICS OF CHINA'S NIOBIUM MATERIAL (Nb2-1)

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 119-120

[Article by Wang Jiasu [3769 1367 4790] and Wang Suyu [3769 4790 3768], Hefei Research Institute of Cryogenics and Electronics Technology: "Superconducting Microwave Surface Resistance of Nb2-1 Material at Liquid Helium Temperature"]

[Text] Text of English Abstract: The experimental research of the superconducting microwave surface resistance with China's niobium material (Nb2-1) at the liquid helium temperature is described. The measurement is made on X-band TE_{011} mode cavity. Unloaded Q_0 value of 4.3×10^{o} is achieved at a temperature of 4.2K. The equivalent residual surface resistance is $1.8 \times 10^{-4}\Omega$.

In superconducting material at very low frequencies, the superfluid current is dominant while the resistance effect is very tiny. Yet surface resistance exists in superconducting material in the microwave frequency band. The superconducting microwave surface resistance measured on X wave band highly pure niobium at a temperature of 1.3K was 1.5×10^{-9} [1]. The High Energy Physics Institute of the Chinese Academy of Sciences measured the superconducting microwave surface resistance of X wave band highly pure (99.98 percent) niobium at 1.87K as $7.8 \times 10^{-6}\Omega$. This paper gives the results of experimental research on a superconducting microwave resonator made of Chinese manufactured industrially pure cast niobium ingot (Nb2-1, 99.7 percent pure) and at 4.2K and 9984MHz the superconducting microwave surface resistance was measured at $1.8 \times 10^{-4}\Omega$.

Superconducting Microwave Resonator System

To measure microwave surface resistance accurately, it is necessary to manufacture meticulously a microwave resonator. The inner diameter and length of the resonator used in the experiments were the same, both 40mm! Two small holes, 4mm in diameter were punched in the resonator's cover plate for input-output coupling of the microwave signal. A hole 3mm in diameter was punched in the center of the bottom plate as a channel for creating a vacuum. After mechanical polishing, the resonator was polished chemically in a triacidic (HF, HNO_3 and H_2SO_4) solution[2] but before polishing the three components, they were first heated appropriately. The function of the H_2SO_4 in the triacidic solution was to slow down the rate of the corrosion of the niobium; the

aim of appropriate heating was to obtain a bright level surface, but only when the triacidic mix, heating and corrosion time were optimal could satisfactory results be achieved. In particular, the time should be strictly controlled to obtain ultimately an unusually bright level niobium surface so that the fineness comes close to ▽ 12. The niobium ingot need not be cooled in a high vacuum. After mechanical polishing it was discovered that the grain diameter was approximately 0.6cm. After chemical polished it was immediately washed in ionized water, then cleaned with analytically pure acetic acid. A superconducting niobium resonator processed in this way can realize excellent superconductivity at the temperature of liquid helium. Bright level superconducting material can obtain good electrical performance, but it is necessary for the surface to be clean for it to be able to maintain its superconducting performance. This experiment paid special attention to this problem. After treating the cleaned niobium resonator with acetic acid, it was immediately placed in a stainless steel vacuum cover, the input and output waveguide sealed windows on the upper cover were sealed with microwave ceramic plates and indium wire, and the oxygen-free copper suction tube on the bottom was directly inserted on the oil-less ultrahigh vacuum pumps. First an ultrahigh vacuum was created, then it was heated to about 100°C and the vacuum increased until it reached 1.5×10^{-7}mmHg then it was pinched using high vacuum clamp, and we could make the waveguide microwave resonator used for testing.

The input/output waveguides were made of stainless steel waveguides with walls 0.2mm thick, to ensure constant temperature and thermal separation from the liquid helium temperature area, the inner walls were coated with copper to reduce waveguide loss. The waveguides on the top of the liquid helium dewar vessel flange also had sealed windows of ceramic plate and indium wire as described above. The entire waveguide sealed area was taken to a vacuum of nearly 10^{-2}mmHg, then sealed.

Measurement Results and Discussion

The no-load quality factor Q_o of the resonator was in inverse proportion to the residual surface resistance R_s inside the resonator. The geometrical factors of the TE_{001} superconducting microwave resonator used in this experiment were G=780, $Q_o=780/R_s$. Customarily we used the decay method to measure its Q value.[4] At the temperature of liquid helium, the time it took the drop from the maximum power point to the 3dB was 10μs. Time was measured using a pulse oscilloscope, the wave detector was placed in a completely symmetrical wave detection state, and at the same time measured the standing-wave coefficient ρ, as 1.54, therefore, $Q_L=0.91\times10^6$ and $Q_o=4.3\times10^6$, and the corresponding R_{xs} was $1.8\times10^{-4}\Omega$. Document [5] showed that at 10GHz on the basis of the theoretical computations given in document [6], at 4.2K, the microwave surface resistance of superconducting niobium at 10Ghz $R_s=4\times10^{-6}\Omega$. Document [7] at 9.5GHz on the basis of the theoretical computations given in document [8], at 4.2K, $R_s=2\times10^{-5}\Omega$. Document [9] measured highly pure niobium which has been smelted four-fold by electron beams and at 4.2K and 9.2Ghz, $R_s=1.1\times10^{-5}\Omega$, almost the same as the theoretical value of the method described above in document [8]. Although the new chemical polishing technology [10] and [11] obtained a rather satisfactory niobium surface, due to the limitations of the low purity of the niobium and other conditions, the vacuum inside the resonator could not reach 10^{-9}mmHg, which to a certain degree restricted the improvement of Rs.

A great deal of theoretical and experimental research shows that when the frequency or temperature becomes lower, the surface resistance Rs can become even lower.

Experiments prove that the superconducting microwave surface resistance of domestically manufactured industrially pure Nb2-1 material at 4.2K and X wave band is less than $1.8 \times 10^{-4}\Omega$, its superconducting resonator's Q value reaches 10^6, and thus it can be used in such passive superconducting microwave circuits as superconducting filters, transmission lines and antennas.

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APPLIED SCIENCES

CONFOCAL LASER RESONATOR CHARACTERISTICS ANALYZED

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 5, No 11, Nov 85 pp 992-996

[Article by Jin Deyun [6855 1795 6663], Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences: "A Confocal Laser Resonator"]

[Text] Text of English Abstract: The dynamic oscillation characteristics of a special confocal resonator with G_1=0 and G_2=0 have been analyzed. This resonator shows oscillation characteristics of a Gaussian standing-wave resonator, a critical resonator, and a travelling-wave resonator, respectively, when the direction of the rectilinear-motion equation for the resonator is changed. The method for designing the resonator is proposed. Experimental results are in agreement with theoretical analysis.

I.

Document [1] analyzes in detail the oscillation characteristics of a laser resonator from a theoretical standpoint, and discusses the differences and connections of Gaussian standing-wave resonator, critical resonator and travelling wave resonator. For a laser with a lens type medium, the characterization of the back and forth matrix A of the oscillation characteristics is[1]:

$$\text{A back and forth} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} = \begin{pmatrix} 4G_1G_2 - 2A_0G_2 - 1 & 2B_0G_2 \\ \frac{2A_0}{B_0}\left(2G_1G_2 - A_0G_2 - \frac{G_1}{A_0}\right) & 2A_0G_2 - 1 \end{pmatrix}, \quad (1)$$

in which $G_1 = A_0 - B_0/R_1$, $G_2 = D_0 - B_0/R_2$, $A_0 = 1 - b/f_T$, $B_0 = a + b - ab/f_T$, $D_0 = 1 - a/f_T$. R_1 and R_2 are the curvature radii of the output resonator lens and the rear reflecting lens respectively. a and b are the distances between the front and read chamber lenses and the "basic surface" of the activation medium. f_T is the activation medium thermal focal distance under a definite pumping power. Since the confocal condition C=0 we can obtain the confocal laser resonator equation:

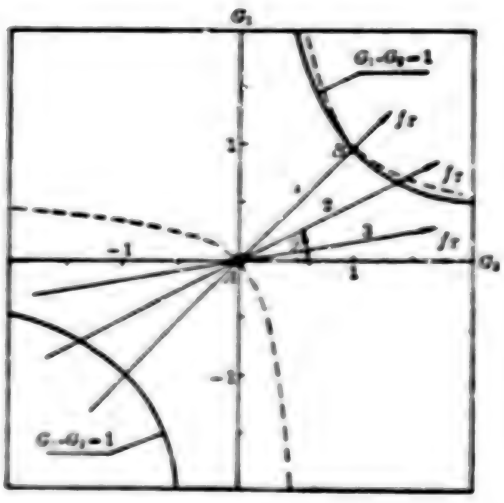
$$2G_1G_2 - A_0G_2 - G_1/A_0 = 0. \quad (2)$$

*Date draft received: 23 April 1985; date revised draft received: 31 May 1985

Figure 1 gives the curves of two confocal resonators A =1, illustrated by the broken lines in the figure. From the results presented in the figure it can be seen that on the confocal curve group there are two characteristic points: A and B. B represents a critical confocal type resonator and since its diffraction loss is great, in actual applications it has a very highly localized nature. However, the confocal resonator represented by A is at a "convergent point" of a Gaussian standing-wave resonator, critical resonator, and travelling wave resonator, thus it has "exotic" characteristics. Since this resonator has relatively low diffraction loss, in the low gain system of a high recurrence rate or continuous solid state laser, this resonator structure is more often adopted. This paper is based on this point and from a theoretical perspective analyzes its dynamic oscillation characteristics, discusses how resonator parameters can be rationally selected, and finally, obtains rather satisfactory results experimentally.

Figure 1.

Dynamic stability diagram of confocal laser resonators



II.

Laser resonator oscillation features are characterized by the characteristic wave surface curve radius R_c [1]:

$$R_c = B/\sqrt{g^2-1}, \tag{3}$$

in which g=(A+D)/2. Changes in the resonator structure caused by irregular disturbance of the activation medium thermal focal length f_T are reflected in the dynamic stability diagram as a straight line motion equation[2]:

$$G_2 = \eta G_1 + B_2, \tag{4}$$

in which $\eta = a(1-b/R_2)/b(1-a/R_1)$, $B_2 = 1-(a+b)/R_2 - \eta(1-(a+b)/R_1)$, η, B_2 are the slope and the intercept. Taking the angle of this straight line and the axis G_2 as θ, as illustrated in Figure 1, it is not difficult to obtain:

$$\theta = \mathrm{ctg}^{-1}\eta. \tag{5}$$

Clearly, for the confocal resonator $G_1=G_2=0$, $B_2=0$. The corresponding characteristic wave surface curvature $R_{c,cof}$ is

$$R_{c,cof}=\begin{cases} iB_0\sqrt{\eta} & 0<\theta<\pi/2,\ \pi<\theta<3\pi/2, \\ B_0\sqrt{|\eta|} & \pi/2<\theta<\pi,\ 3\pi/2<\theta<2\pi, \end{cases} \tag{6}$$

in which $i=\sqrt{-1}$. The results of Eq. (6) show: when $0<\theta<\Pi/2$ or $\Pi<\theta<3\Pi/2$, $R_{c,cof}$ is a complex number, therefore for a Gaussian standing-wave resonator, the corresponding fundamental mode beam scattering angle $\alpha_{1,cof}$ is[1]

$$\alpha_{1,cof}=K/(B_0\sqrt{\eta})^{1/2}, \tag{7}$$

in which $K=\sqrt{\lambda/\pi}$, λ is the laser wave length. When $\Pi/2<\theta<\Pi$ or $3\Pi/2<\theta<2\Pi$, $R_{c,cof}$ is a real number, therefore for the travelling wave resonator, the corresponding spherical surface wave curvature radius R_{cof} is [1]

$$R_{cof}=\left(\frac{1}{R_1}+\frac{1}{B_0\sqrt{|\eta|}}\right)^{-1}. \tag{8}$$

Clearly, when $\theta=0$ or Π, it is a confocal critical resonator. The results of Eqs. (7)-(8) show: for a confocal laser resonator in which G_1 and G_2 are always zero, not only benzheng [2609 1767] oscillation mode (Gaussian or point beam), but moreover the orientation of the output characteristics (beam scattering angle or spherical wave curve) is very closely related to the rectilinear-motion equation (4) on the dynamic stability diagram. In other words, the orientation of the rectilinear-motion equation (4) is different and the confocal resonator has the oscillation characteristics of Gaussian standing-wave resonator, critical resonator, and travelling-wave resonator, respectively.

For the confocal Gaussian standing-wave resonator, the fundamental wave beam scattering angle $\alpha_{1,cof}$ is in inverse proportion to $\eta^{1/4}$, $P_{02}^{1/2}$. Thus, the smaller the value of θ, the longer f_T (corresponding B_0 value is large), and the brightness of the corresponding output laser is high. Yet, the radius R_{cof} of the output spherical wave curvature of the confocal travelling-wave resonator is not only determined by the size of the f_T and θ, but also is related to the radius R_1 of the curvature of the output resonator lens.

III.

The confocal resonator structure parameters a, b, R_1, and R_2 with the activation medium thermal focal distance f_T satisfy the equation

$$\frac{a(1-b/R_2)}{1-(a+b)/R_2}=\frac{b(1-a/R_1)}{1-(a+b)/R_1}=f_T.$$

In the actual process of operating the laser, it is frequently difficult to avoid random disturbance of the medium's thermal focal distance f_T. For a confocal resonator of a definite structure, disturbance of f_T leads to the distortion of the confocal resonator into a non-confocal. Taking $m=G_1\cdot G_2$, and

using m as a parameter, the changes in the radius R_c of the corresponding characteristic spherical wave curvature according to Eq. (4) is

$$R_c = R_{c.\text{out}}/(|m-1|)^{1/2}. \tag{9}$$

Change of m with f_T is

$$m = \eta[1-(a+b)/R_1 - b(1-a/R_1)/f_T]^2. \tag{10}$$

Clearly, Eqs. (9) and (10) reflect quantitatively the dynamic oscillation characteristics of the confocal resonator. Figures 2 and 3 give the curve of dynamic changes of the characteristic wave curvature R_c-G_1 with the equivalent G factor G_1-f_T. The results show that when the activation medium's thermal focal distance f_T is deflected from the f_{To} value corresponding to the confocal resonator, the changes in R_c causes by increasing changes in the direction of f_T the changes in f_T along the contraction direction are much smaller. Next, for confocal Gaussian standing-wave resonators with a resonator structure having a large θ value, the thermal stability of corresponding R_c with changes in f_T is pretty good (see Figure 2). These useful conclusions are very important for rational design of confocal resonators.

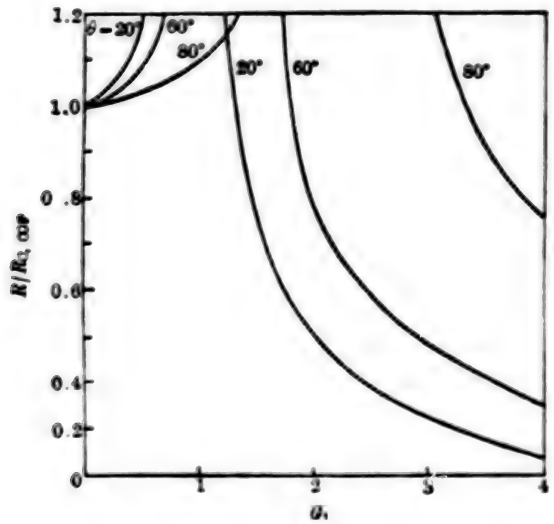


Figure 2. Characteristic wave-front curvature R_c vs. θ

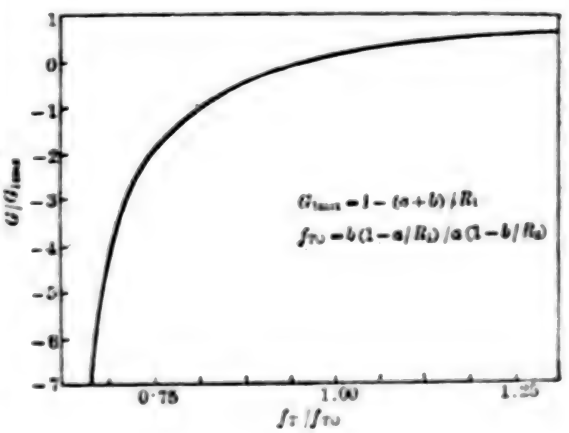


Figure 3. Equivalent factor G_1 vs. length f_T

IV.

Summarizing the above, oscillation characteristics of confocal resonators have an intimate relationship with its orientation of the rectilinear-motion equation (4) in the dynamic stability diagram. After selecting an activation medium and determining the medium's thermal focal length f_T corresponding to a definite pumping power, on the basis of the different demands of actual use for laser output, we can rationally select the resonator parameters:

1. Corresponding to different applications goals and the size of the gain of the activation medium used, the Gaussian standing-wave resonator or travelling-wave resonator should be used. For most low gain systems, the confocal Gaussian standing-wave resonator is appropriate.

2. On the basis of the type of resonator used and the results of Eq. (6), the value of θ should be selected appropriately and at the same time, because of the demands of actual application on the output beam scattering angle $\alpha_{1,cof}$ (or spherical wave curvature radius R_{cof}), selected an appropriate value for $R_{c,cof}$, and make the values of θ and $R_{c,cof}$ design parameters.

3. Solve the following non-linear equation group, and obtain the confocal resonator structural parameters a, b, R_1 and R_2:

$$\begin{cases} 1-\dfrac{a+b}{R_1}-\dfrac{b(1-a/R_1)}{f_T}=0, \\ 1-\dfrac{a+b}{R_2}-\dfrac{a(1-b/R_2)}{f_T}=0, \\ a\left(1-\dfrac{b}{R_2}\right)-\eta b\left(1-\dfrac{a}{R_1}\right)=0, \\ \sqrt{\eta}\left(a+b-\dfrac{ab}{f_T}\right)-R_{c,cof}=0, \end{cases}$$

in which $\eta=\mathrm{ctg}\theta$.

4. On the basis of design results, compute quantitatively the output chacteristics of the confocal resonator:

fundamental mode scattering angle: $\alpha_{1,cof}=K\cdot(\mathrm{tg}\theta)^{\frac{1}{2}}\cdot B_0^{-\frac{1}{2}}$

(for Gaussian standing-wave resonators)

spherical wave curvature radius: $R_{cof}=\dfrac{B_0R_1(:\eta:)^{\frac{1}{2}}}{R_1+B_0(:\eta:)^{\frac{1}{2}}}$

(for travelling-wave resonators)

5. On the basis of Eqs (9) and (10), analyze quantitatively the dynamic output characteristics of the confocal resonator.

If the output beam scattering angle $\alpha_{1,cof}$ or spherical wave curvature radius R_{cof} of the laser resonator designed cannot satisfy the actual application demands, the θ and $R_{c,cof}$ values can be appropriately revised until a satisfactory confocal resonator has been designed.

V.

Using a low gain continuous YAG laser as an example, we carried out experimental researches on the oscillation characteristics of a confocal type Gaussian standing-wave resonator. The dimensions of the YAG rod were ϕ5mm x 105mm, $R_1=\infty$, R_2 was a flat or concave lens. Output resonator lens transparency was 11 percent. The collecting resonator was an single elliptical cylindrical LK-8x75 krypton light pump resonator with an effective length of 100mm. Output power was measured with a JGK-3 laser power meter. The multi-mode laser scattering angles were obtained by direct measurement.

During the experiments, confocal resonators of three different structures were used. The resonator structural parameters, the theoretical computational values, and the results of experimental measurements are given in Table 1. The results show that comparing #3 resonator to #1 resonator, the θ value is 4.5-fold smaller, laser beam scattering dropped by 2.4-fold, and brightness correspondingly increased by 6.3-fold. Comparing #2 resonator with #1 resonator, the θ value is smaller by 1/3, and brightness increased by 1.7-fold. Viewed from the angle of observation results of output stability experiments, #1 resonator output is more stable, #2 resonator is next, and #3 is the poorest. In addition, measurements of multi-mode beam scattering angle α_1 were pretty close to theoretical computed values. From this it can be seen that the conclusions reached in the theoretical analysis of confocal resonators given in this paper are basically correct. These conclusions have definite guiding significance for application of confocal resonator technology.

Table 1. Structures and Experimental Results and Confocal Resonators

Order		1	2	3
Resonator parameters	a(cm)	30	39	65
	b(cm)	30	30	26
	R_1(cm)	∞	∞	∞
	R_2(cm)	∞	-100	-20
Thermal focal distance f_T(cm)		30	30	30
Orientation	θ(°)	45.0	30.6	9.9
	B_2	0	0	0
Beam scattering angle α_1(m rad)		5.89	4.53	2.72
Measured values	output power (W)	12.01	9.20	7.13
	beam scattering angle(m rad)	5.41	4.10	2.21
	brightness $\frac{10^6(W)}{cm^2 \cdot stero.\ rad.}$	1.039	1.811	6.574

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APPLIED SCIENCES

CHINESE ACADEMY OF SCIENCES STUDIES DH LASER

Beijing TONGXIN XUEBAO [JOURNAL OF CHINA INSTITUTE OF COMMUNICATIONS] in
Vol 6 No 1, Jan 85 pp 65-70

[Article by Wang Qiming [3769 0796 2494] of the Institute of Semiconductor,
Chinese Academy of Sciences: "An Investigation of Co-Cavity Two-Section (CCTS)
DH Lasers"]

[Text] Abstract: This paper reports an investigation of CCTS AlGaAs/GaAs,
InGaAsP/InP DH lasers. It is shown that CCTS DH lasers have multiactive
characteristics both in steady states and in transient states. As a three-
terminal device, the lasing state may be controlled by selecting the operating
mode such as "on" or "off" and by controlling the pulse sequence. It is
interesting that bistable behavior in the output can be obtained in the CCTS
under appropriate experimental conditions.

Introduction

The rapid development of large capacity long distance single mode fiber
communication has posed new challenges on the carrier light sources--semiconductor
lasers. They must not only have a million hours of service life to insure the
reliability of the communication system but also have stable dynamic single
frequency output and as many controllable features as possible. Semiconductor
lasers with distributed feedback (DFB) and distributed reflectors (DBR) based
on the Bragg diffraction effect of the semiconductor grating were once thought
to be promising multifunction single frequency lasers; however, since the
technology for grating fabrication is difficult and the yield of component
production is low, efforts in recent years have been directed to the investigation
of composite cavity lasers. The co-cavity lasers still used the conventional
Fabry-Perot resonance but two or more lasers are coupled on the same (active)
waveguide. Examples are the twin cavity guide coupled (TCGC) laser, the co-
cavity twin stimulation (CCTS) laser and the recently proposed cleavage coupled
cavity (C^3) laser. Such composite cavity lasers have two or more source zones
of different states of stimulation and the single frequency laser output is
achieved through the Q-switching or mode-locking effects due to the competition
of laser lights emitted from the different zones. Such lasers may also have
three terminal or multiterminal features such as frequency tuning, picosecond
pulse generation, and bistable output. Such new features will not only satisfy
the multitude of requirements in optical communication but may also advance the
research of high speed signal processing and optical computers.

In this paper we present some preliminary but important results in our study of the AlGaAs/GaAs, InGaAsP/InP CCTS DH composite cavity lasers.

I. CCTS DH Lasers

Figures 1 and 2 show the AlGaAs/GaAs, InGaAsP/InP CCTS DH lasers we have developed. The chips are five-layer structures grown with the conventional LEP technique. The parameters of these lasers can be found in Refs. (1) and (2). The laser in Figure 1 has a cavity length of 555 μm, a strip width of 15 μm, the source region has a thickness of d = 0.5 - 1.0 μm and the high resistance isolation is fabricated with a proton bombardment technique. The electrode isolation troughs are photoetched before the chip is divided into laser tube chips. The trough width is 5 μm and the trough is made with a selective etching method. The trough bottom is located as close to the top of the source zone as possible to avoid charge leakage in the lateral direction. The isolation resistor should have several thousand ohms if possible so that the laser is divided by the trough into two electrically isolated and optically connected zones: LD_1 and LD_2. The two zones can be supplied independently with power and by adjusting the voltage injected into the two zones, the output characteristics of the laser may be controlled, making it effectively a three-port device. Devices of this structure can only be coupled positively and the heat dissipation is poor. The device with a strip width of 15 μm should only be operated in the pulse mode at room temperature because the threshold current is relatively high.

Figure 2 shows a InGaAsP/InP CCTS laser that we developed. It also has a proton bombarded strip structure and, before forming into tube chips, high resistance zones of various dimensions are formed by proton bombardment in a direction perpendicular to the strips. The laser cavity is 200-300 μm long and the width of the high resistance zone is b' = 15-30 μm. It is really a special case of the device shown in Figure 1 because LD_2 maintains an injection current $I_2 = 0$. Since this device can be reverse coupled and the heat dissipation is good, it can be operated in the CW mode at ambient temperature.

II. Improved CCTS and Control of the Output Characteristics

Using LD_2 as the control port to select a constant injection current I_2 and using LD_1 as the working port to continuously vary the injection current I_1, one can obtain a set of output characteristics curves $L\text{-}I_2\text{-}I_1$. Figure 3 shows the experimental output curve of the 25 AlGaAs/GaAs CCTS operated in a pulsed mode under ambient temperature. As can be seen, no kinks are observed in the experimental output power range of the laser, the laser may be regarded as operating in the single wire stable mode. The threshold current of the laser is I_{tho} and the corresponding current density is J_{thoo}. The solid lines are a set of output curves obtained in separate feeding and using I_2 as the reference current. As shown in the figure, when $J_2 < J_{tho}$ or $I_2 < I_{tho}$, the working threshold current I_{th1} increases rapidly as I_2 decreases and the external differential quantum efficiency η drops substantially. Conversely, when $I_2 > I_{tho}$ or $J_2 > J_{tho}$, I_{tho} also decreases when I_2 increases, but the external differential quantum efficiency η remains a constant. The "on" and "off" of the CCTS laser

can therefore be controlled by adjusting I_2 and the internal modulation of the output light of the CCTS laser can also be achieved through I_2 injection.

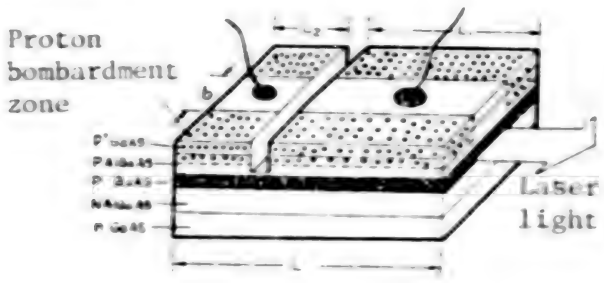

Figure 1. Schematic Diagram of the Structure of a Trough Isolated AlGaAs/GaAs CCTS DH Laser

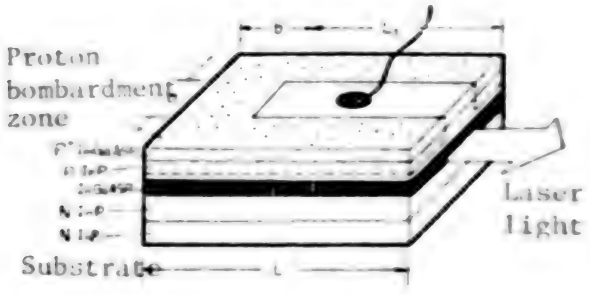

Figure 2. Schematic Diagram of the Structure of a Proton Bombarded InGaAsP/InP CCTS DH Laser

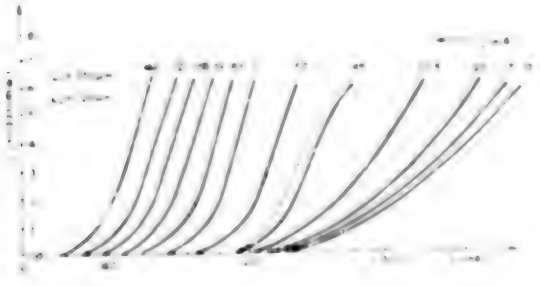

Figure 3. Light Intensity Versus Current L-I_2-I_1 Curves of 43 AlGaAs/GaAs CCTS DH Laser

analyzed the gain coefficient g (positive or negative) of the source of the laser using a linear approximation[3]:

$$g=\beta(J-J_0) \qquad J>J_0 \qquad (1)$$

$$g=\beta'(J-J_0) \qquad J<J_0 \qquad (2)$$

where J_0 is the zero gain intercept current density and β and β' are two states of the source zone. Experimentally we have proven that the ratio

$$\zeta=\beta'/\beta$$

is greater than 1. The analysis results show as follows:

1. When I_2 < J_0, I_{th1} and I_2 satisfy the following relationship

$$I_{th1}+I_2=I_{th} \quad \text{(constant)} \qquad (3)$$

2. When I_2 > J_0, we have

$$I_{th1}+\zeta I_2=I_{th}+(\zeta-1)I_0 \qquad (4)$$

Experimental results agree with (3) and (4) very well. These two equations can, therefore, be used as a basis for selecting the injection current to control the operation of the CCTS.

Figure 3 shows the L-I_1-I_2 curve of another CCTS laser. Judging from the parallel injection characteristics curves (dashed lines), the laser is operating in the multiwire mode[4], and there are two kinks in the curve. It is well known that nonlinearity is a major problem that is yet to be overcome in optical communication. Transient noise may lead to bit errors. In the CCTS laser shown in Figure 4, however, the power at the kink will move up when I_2 is supplied with a low voltage and maintains a negative gain. The output characteristics of the laser are therefore improved considerably in the required power levels.

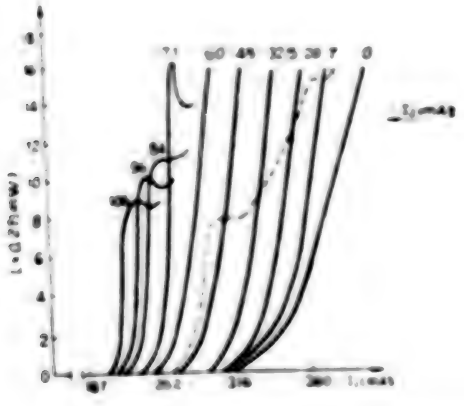

Figure 4. Light Intensity Versus Current L-I_2-I_1 Characteristics of the 22 AlGaAs/GaAs CCTS DH Laser

Atomically bombarded strip lasers generally have a wider strip-width (10-15 μm) and are more likely to have nonuniform multiwire problems. They may have some variations in their effective bandgap (and therefore the emitted wavelength). At a low injection voltage (low electron density), the refractive index of the material is mainly determined by the dielectric constant of the crystal, and wires with a small bandgap have a large dielectric constant and therefore a large refractive index. Conversely, a large bandgap corresponds to a small refractive index. Because of the step in refractive index at the boundary of the two adjacent fibers, the one with the smaller bandgap will become a constraint waveguide and the one with the larger bandgap will become a drain waveguide. The optical limiting factors $\Gamma(1) > \Gamma(2)$. With other parameters remaining the same, the threshold current density $J_{th}^{(1)}$ for stimulated emission of l_1 with the smaller bandgap is smaller than $J_{th}^{(2)}$ of l_2. In addition, they also satisfy the following relationship:

$$J_{th}^{(1)}/J_{th}^{(2)} = \Gamma(2)/\Gamma(1) \tag{5}$$

As a result, l_1 first emits short wavelength and operates in the single wire mode with a linear output. Then, as the injection current increases, l_1 begins to have stimulated recombination and, since the lifetime of the injected carriers is very short (10^{-9} sec), the electron density in the conduction band no longer increases, neither does the effective refractive index. However, l_2 has not reached the threshold and its electron density increases with the injection current, becoming more and more a gain waveguide. The constraint waveguide behavior of l_1 gradually decreases until l_2 has stimulated emission. If we write $\Delta I_{th} = I_{th}^{(2)} - I_{th}^{(1)}$, then the kink occurs in the transition region and there may even be a dip or a negative effective differential efficiency. If ΔI_{th} is small, the kink will occur "earlier" (at a lower power). On the other hand, a large ΔI_{th} will cause the kink to occur at a higher power and the laser will remain in the single wire mode for a greater injection current and have a greater range of linear power output.

Beginning with the CCTS steady state continuity equation, the threshold currents of l_1 and l_2 can be found and ΔI_{th} is therefore given by

$$\Delta I_{th} = \frac{A}{\beta}\left[\frac{1}{\Gamma(2)} - \frac{1}{\Gamma(1)}\right] + \frac{\beta'(2)-\beta'(1)}{\beta}(I_{th}-I_1), \quad I_1 < I_{th} \tag{6.a}$$

$$\Delta I_{th} = \frac{A}{\beta}\left[\frac{1}{\Gamma(2)} - \frac{1}{\Gamma(1)}\right], \quad I_1 > I_{th} \tag{6.b}$$

where $\beta'(2)$ and $\beta'(1)$ are the negative gain linear approximation factors of l_1 and l_2 respectively. For a given emission wavelength, the second term in (6.a) is always positive since $\beta'(2) > \beta'(1)$. The positive gain linear approximation factor β may be regarded as the same for l_1 and l_2. A is a parameter that determines the threshold current and depends on the internal parameters of the device. Therefore, ΔI_{th} of the CCTS may be increased if l_2 is made smaller than l_1, the "kink" power will be moved up, the linear output range will be greater and the light source requirements for optical communication will be easier to satisfy.

III. Pulse Sequence of CCTS

Some semiconductor lasers may have sustained spontaneous pulse outputs at a certain current due to various physical causes such as mode conversion, optical inhomogeneity in the cavity and unstable transverse mode conversion. The occurrence of such pulses are not controllable and it limits the application of semiconductor lasers in high speed communication. People have tried various methods to suppress such pulses. However, if the generation of such pulses can be controlled, they can actually be a microwave self-modulation output or even CW output (the repetition rate is usually a few hundred to a few thousand megahertz), and may have great potential in other applications.

In the 1960's Bascov[5] has studied the transient behavior of homojunction GaAs laser which at the time could only be operated at low temperature (77K). We have made some preliminary observation of the transient behavior of CCTS DH lasers. Figure 5 shows the measured results of 55 AlGaAs/GaAs CCTS DH laser. To prove that such light pulses are not "spontaneous," we have operated the laser with two zones in parallel and found no light pulses. When the two zones were powered separately, we obtained the results in Figure 5.

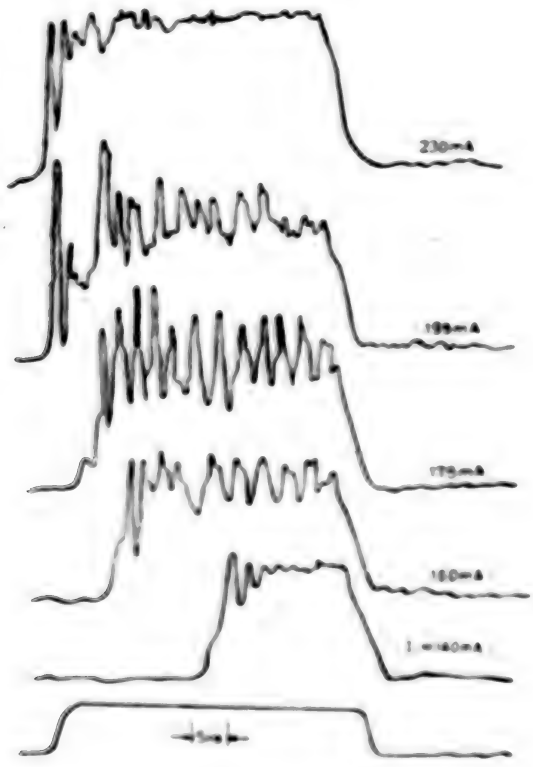

Figure 5. Transient Characteristics of 55 AlGaAs/GaAs CCTS DH Laser at I_T = 215 mA

The electron and photon densities of the source zone in the CCTS laser satisfy the following rate equations:

$$\frac{dn_1}{dt} = \frac{J_1}{qd} - g_1 S - \frac{n_1}{\tau} \tag{7}$$

$$\frac{dn_2}{dt} = \frac{J_2}{qd} - g_2 S - \frac{n_2}{\tau} \tag{8}$$

$$\frac{dS}{dt} = (g_1 + kg_2)V_g S + \frac{\beta}{\tau}(n_1 + kn_2)V_g - \frac{S}{\tau_p} \tag{9}$$

$$g_1 = \beta(n_1 - n_0) \quad g_2 = \beta'(n_2 - n_0)$$

Here $k = L_2/L_1$, $V_g = L_1/(L_1 + L_2)$, β is the spontaneous radiation factor, τ is the spontaneous recombination life of the electron, τ_p is the lifetime of the photon in the cavity, g_1, g_2 are the gain coefficients in LD_1 and LD_2 respectively, n_1 and n_2 are the electron density in LD_1 and LD_2, and J_1 and J_2 are respectively the injection current densities in LD_1 and LD_2 (not counting the spontaneous radiation term in Eq.(9)). Under the small signal condition of Basov (actually representing fast decay light pulses), the condition for the generation of light pulses is

$$\begin{array}{ll} g_1 > g_2, & g_2 < 0 \\ \text{i.e.,} J_1 > J_{th}, & J_2 < J_0 \end{array} \tag{10}$$

We analyzed the large signal approximation for producing equal amplitude spontaneous pulses and found it to be

$$J_1 > \frac{k}{1+k}(J_{th} + J_0) + \frac{1}{1+k}(kJ_2 - (1-k)J_0 + (k+1)J_{th}), \quad J_2 < J_0 \tag{11}$$

where J_1 and J_2 are the injection current densities in LD_1 and LD_2 respectively, J_{th} is the threshold current density for parallel injection, and J_0 is the zero gain current density. Figure 6 shows the pulse operation region in phase space based on the conditions (10) and (11). The area shaded by dashes is the current region for producing equal amplitude pulses in the CCTS. The experimental results are not yet in agreement with the theoretical prediction (dots in the figure) and further research is needed. Nevertheless, Figure 6 shows that the light pulse sequence can be controlled as long as the operating condition of the CCTS is properly chosen.

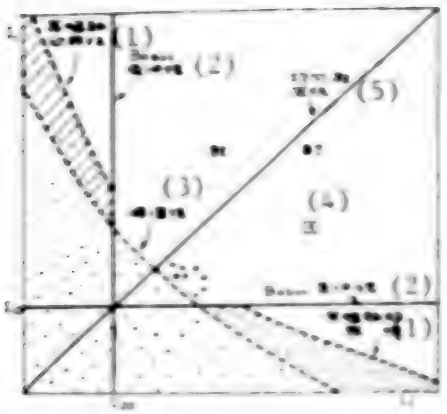

Figure 6. Pulsing Operation Region of CCTS DH Laser in the Phase Plane

Key:

1. Boundary for constant amplitude pulse
2. Basov condition line
3. Threshold line
4. Stimulated emission region
5. Uniform stimulation line

IV. Bistable Characteristics of the CCTS Output

Bistable light output is one of the research topics of current interest. A number of ways have been devised to produce bistable characteristics in the light output. CCTS DH lasers may prove to be an important, simple, and practical method. Optical flipflops may be developed into miniaturized solid state optical enhancement relays in optical communication and their optical logic function may also serve as the basis of optical computers. An optical flipflop of practical value must have sufficient dynamic range, sufficiently fast response and stable output modes.

Figures 7 and 8 show the bistable characteristics[6] of two InGaAs/InP CCTS devices fabricated according to the structure of Figure 2. When the current I_1 increases from zero, CCTS begins with spontaneous radiation and the optical output follows the path of the low state. When I_1 exceeds $I_1(1)$, CCTS DH suddenly gives off stimulated emission due to the action of the internal Q switch. The output light intensity abruptly jumps to the high state S(1) and then follows the path of the high state. When the current is decreased, since the CCTS cavity has already gone through a phase change and is filled with photons, the output returns along the high state path and the stimulated emission is present until I_1 drops below $I_1(2)$, and the intensity S(2) suddenly drops to zero. $\Delta I = I_1(1) - I_1(2)$ is the dynamic range of the current and in this range CCTS has bistable characteristics.

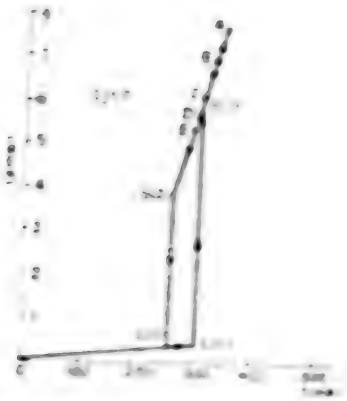

Figure 7. Bistable Characteristics of 83-A1 InGaAs/InP CCTS DH Laser Output

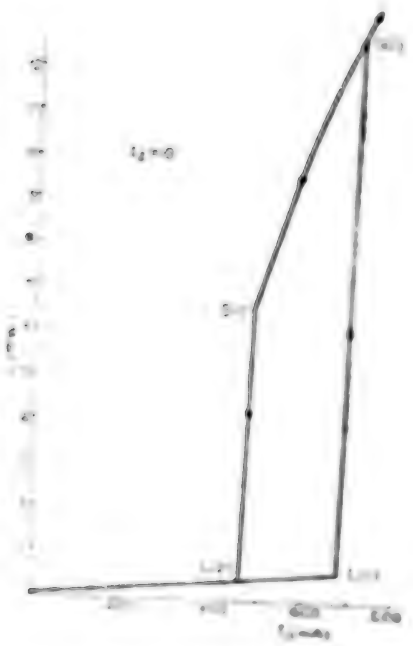

Figure 8. Bistable Characteristics of 83-815 InGaAs/InP CCTS DH Laser Output

Treating Eqs. (7), (8), and (9) as simultaneous equations and ignoring the contribution of the spontaneous radiation, we obtain the steady state photon density (S) of the CCTS:

$$S\left[K_1(\beta)\frac{J_2-J_0}{qd(1+(\beta\tau_s)^2)}+K_2(\beta)\frac{J_2-J_0}{qd(1+(\beta\tau_s)^2)}\frac{1}{\tau\tau_s}\right]=0 \tag{12}$$

$$K_1=V_g,\quad K_2=kV_g,\quad J_0=\frac{qn_0d}{\tau}$$

Valid solutions of Eq.(12) are $S \geq 0$.

Let $J_2 = 0 < J_0$ and follow the analysis in Ref.[7], we have

$$J_1(1)=J_0(1-\zeta k)+\frac{qd}{(\beta\tau_s)^2\tau_s} \tag{13}$$

$$J_1(2)=(1+k)J_0+\left(\frac{1}{\beta_2}-\frac{1}{\beta_1}\right)\frac{qd}{\tau\tau_s^2}+2\left[\left(\frac{1}{\beta_2}-\frac{1}{\beta_1}\right)^2\frac{kqdJ_0}{\tau\tau_s^2}\right]^{1/2} \tag{14}$$

$$\Delta J=J_1(1)-J_1(2)=k(\zeta-1)J_0-\frac{qd}{(\beta_1\tau_s)^2\tau_s}-2\left[\left(\frac{1}{\beta_2}-\frac{1}{\beta_1}\right)^2\frac{kqdJ_0}{\tau\tau_s^2}\right]^{1/2} \tag{15}$$

where d is the thickness of the source zone, and q is the electronic charge. As can be seen, the value of ΔJ depends on k ($= L_2/L_1$). Equation (15) may serve as a reference for device design. According to the theoretical analysis of Ref.[7], (15) is valid only when $L_2 > 0$.

Figure 9 shows the output spectrum of the high state of one of the CCTS described above. It is significant that CCTS maintains a rather stable frequency output over a wide range of current. The halfwidth of the spectral line is $\Delta\lambda < 1\text{Å}$, the resolution limit of the equipment. The stability of the peak wavelength is as high as 10^{-5}. It is a very stable single frequency light source and very valuable in both optical communication and in signal processing.

We have measured the transient response of the CCTS and found that, except for a relatively long delay (about 50 ns, smaller at higher currents), the response time is of the order of ns. Making use of this, we adjusted the width and amplitude of the stimulating pulse and obtained single ultrashort pulse output from the CCTS. The pulse width is at most 500 ps (limited by the bandwidth of the oscilloscope). The result is shown in Figure 10.

Our experiments show that CCTS lasers, as an optical bistable device, have good potentials in their output characteristics, current dynamic range, spectral mode, and response speed.

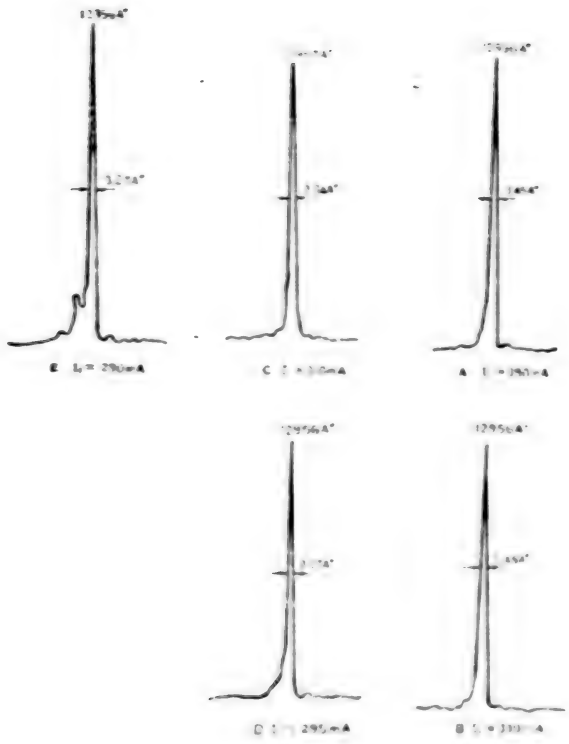

Figure 9. Stimulated Emission Spectrum of the 83-Al InGaAs/InP CCTS in the High State Under a Different Current (I_2 = 0) and at 300K

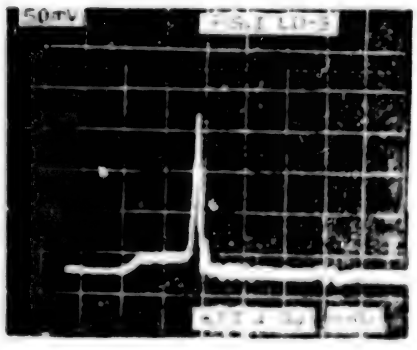

Figure 10. Single 500 ps Light Pulse From a InGaAs/InP CCTS Laser (horizontal axis 5 ns per division)

Conclusion

The two types of CCTS DH lasers described here have simple structures and the fabrication technique has also matured. Judging from the measurement results obtained to date, it already has a number of useful features and functions. Of particular interest is that the optical bistable function may be applied to optical enhancement relays in optical communication and may also serve as the basic unit in optical logic operations. To meet the requirements in practical applications, we must continue improving the structure of the device and further reduce the threshold current and the power consumption.

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APPLIED SCIENCES

DEVELOPMENT OF SECTIONAL CONSTRICTED PLANAR CO-CAVITY DH LASERS

Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 6 No 4, Jul 85 pp 442-445

[Article by Du Guotong [2629 0948 0681], Jilin University; Yang Deling [2799 1795 2651], Chongqing Institute of Optoelectronic Technology and Gao Dingsan [7559 7844 0005], Jilin University; manuscript received 16 Oct 84]

[Text] This article reports the development of sectional constructed planar co-cavity DH lasers. At present lasers with a cavity length of 135μm and DC threshold values of 30mA (27°C) have been manufactured. Initial hypotheses for analyzing the mode characteristics for equivalent values over the whole cavity are suggested.

Not long ago in this journal, the manufacture and special characteristics of a new kind of refraction-steered and gain-steered laser of co-cavity structure, i.e., the sectional constricted planar co-cavity laser (SCP), designed and reported by us in [1]. This kind of laser has good linear light-power/current-flow curves, and compared with pure ridge-waveguide constricted lasers (CDHs) can preserve a larger power range in base horizontal mode and pure vertical mode operation. Because of limiting circumstances, at that time the lasers' current thresholds were still rather high.

To reduce the current thresholds and raise the reliability of the lasers, to make this kind of laser more practical, we carried out a great deal more experimental work, using improved extruded powder to make the epitaxies, improving the quality of the epitaxial layers. At the same time, adjustments were made in the rate of heat dissipation of the epitaxial layers and in the thickness of each layer, and a shorter cavity structure was used. At present we have already manufactured batch quantities of SCP lasers with thresholds of 30-40mA that can continuously operate at room temperature; the overall cavity length of the lasers is 90-150μm, the CDH section occupying 1/3-2/3. Figure 1 gives the light-power curves of several of those lasers. The two with the lowest threshold values are 852#, with an overall cavity length L=90μm, CDH section cavity length Lc=40μm, a tube-core pulse threshold of 25mA, and direct current threshold value of 29mA (22°C) and 821# with L=135μm, Lc=65μm, and 27°C direct current threshold of 30mA. To give a comparative explanation of the stability of SCP lasers in the lateral mode, the light-power curve of an oxide DH laser of the same width shows deviation in the power curve at about 2-3mW.

To observe the SCP laser's ability to preserve good linearity of the light-power curve in high power ranges, we turned the output power of some lasers to above 18mW, and they still manifested good linearity, as Figure 2 shows.

Previously we carried out observations of the near-field pattern of the SCP lasers. This time we carried out tests of the SCP lasers' far-field patterns. The tests made clear that the light beams outputted by the face of the two cavities showed good single peaks, the angle of divergence was within the range of 8-13°, and the base-mode oscillation could be preserved at 2-2.5 times the threshold value, about in the range of 15mW, as Figure 3 shows.

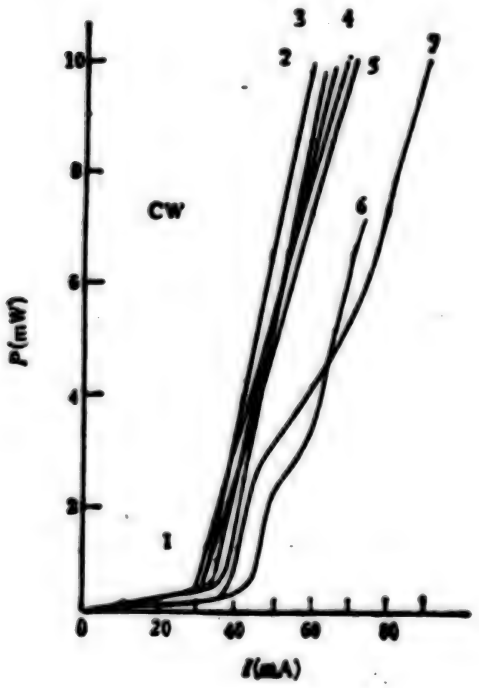

Figure 1. Light-power/current-flow curves for SCP and OS lasers with the same epitaxial layers: (1) SCP#852 (2) SCP#821 (3,4,5) SCP lasers (6,7) OS lasers

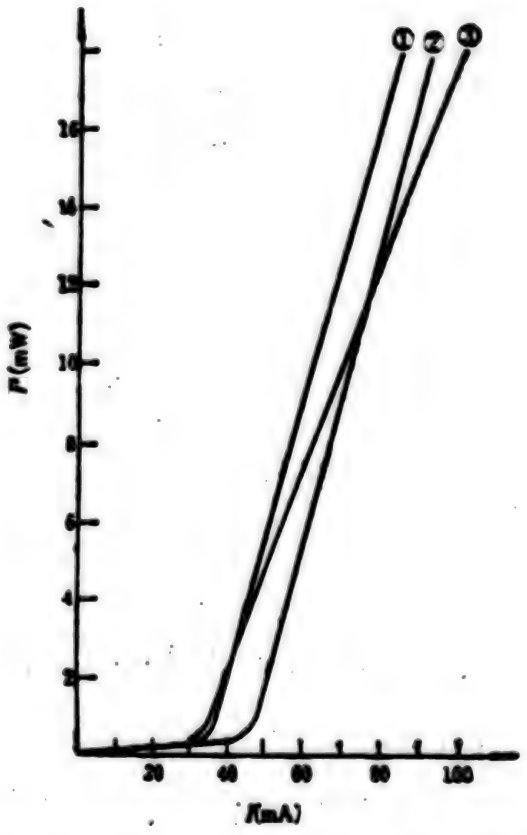

Figure 2. Light-power curves of SCP lasers: (1) SCP#037 (2) #040 (3) #039

We also carried out aging screenings on some of the lasers, under conditions of room temperature (about 25°C) at a steady 2mW output for 150 hours, with a rate of change of less than 5 percent. The screening results made clear that SCP lasers can have high reliability, and that their ratio of [acceptable] finished products can on the whole equal that of proton bombardment DH lasers. In Figure 4 we give the current-change curve of the 646# SCP laser operating continuously with a 2mW output at 25°C. It can be seen that after the laser was operating more than 96 hours, the working current needed for a 2mW output did not increase. According to consistent experience with proton bombardment

laser aging screenings, a laser with this kind of steady performance ordinarily has a life exceeding 5,000 hours.

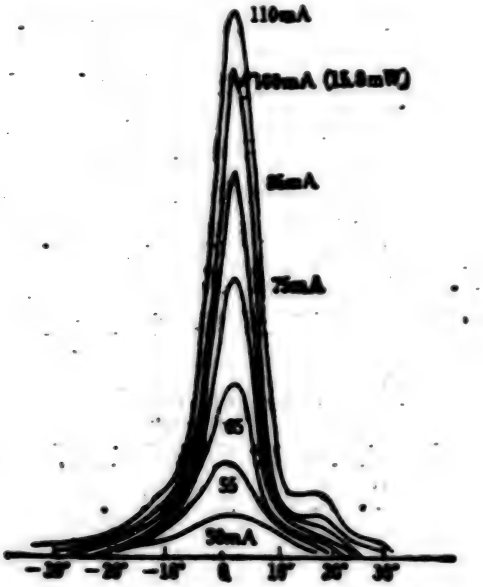

Figure 3. Far-field light-intensity distribution of SCP lasers, tested at 30°C with a 1:14 pulse/duty ratio

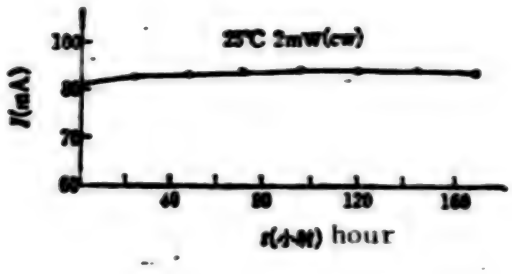

Figure 4. Changes over time in the operating current during aging of SCP laser 646#

Using theory to interpret the lateral-mode stability and selectivity of SCP-structure lasers is an important topic, because the SCP laser structure involves three-dimensional changes, but present models of laser theory are all two-dimensional. This way, one must either expand two-dimensional models to the three-dimensional situation, or simplify the three-dimensional situation to a two-dimensional model for treatment. Now we hypothesize $\bar{n}_{C,eq}(\gamma)$ as the CDH section's effective rate of refraction, $\bar{n}_{O,eq}(\gamma)$ as the equivalent rate of refraction in the OS section. In regard to a light wave from a completely certain propagation model, the phase velocity in the CDH section $v_C = \frac{c}{\bar{n}_{C,eq}}$, the OS section's phase velocity $v_O = \frac{c}{\bar{n}_{O,eq}}$.

Thus the time required for a certain equal-phase face to pass through the two sections is $\tau_C = \frac{L_C}{v_C} = \frac{L_C}{c}\bar{n}_{C,eq}$, $\tau_O = \frac{L_O}{c}\bar{n}_{O,eq}$. If the reflection, diffraction and other phase changes at the interface of the CDH and OS sections are ignored, the time required for the equal-phase face to pass through the whole resonant cavity

$$\tau = \tau_O + \tau_C = \frac{L_C}{c}\bar{n}_{C,eq} + \frac{L_O}{c}\bar{n}_{O,eq}$$

Now we define a physical quantity called whole-cavity equivalent refraction,

$$\bar{n}_{a,eq} = \frac{L_C}{L}\bar{n}_{C,eq} + \frac{L_O}{L}\bar{n}_{O,eq}$$

and have

$$\tau = \frac{L_c}{c}\bar{n}_{c,eq} + \frac{L_0}{c}\bar{n}_{0,eq} = \frac{L}{c}\bar{n}_{a,eq}$$

It can be seen that na,eq can equivalently characterize some waveguide characteristics of the SCP laser. Defining another physical quantity, called the whole-cavity average gain:

$$g(\gamma) = \frac{L_c}{L}g_c(\gamma) + \frac{L_0}{L}g_0(\gamma).$$

At the same time we bring out the two hypotheses below: first, the sectional refraction gain-steering co-cavity laser's lateral mode selectivity and waveguide strength is determined by the $\bar{n}_{a,eq}(\gamma)$ change regularity. Second, the condition for stability in the lateral mode that $\frac{\Delta\bar{n}}{\bar{n}} + \frac{\Delta g}{g} > 0$ can have $\bar{n}$ and g replaced by the whole-cavity equivalent values and average values, hence $\frac{\Delta\bar{n}_{a,eq}}{\bar{n}_{a,eq}} + \frac{\Delta g}{g} > 0$. In this way we can qualitatively make clear the existence of the OS section in the SCP laser, causing a retardation in the relative changes of $\bar{n}_{a,eq}(\gamma)$ and the CDH section's $\bar{n}_{c,eq}(\gamma)$ in relation to γ, and from this improving the selectivity of the lateral mode. Similarly from the CDH section's existence throughout the process of the SCP laser's operation there is a positive $\frac{\Delta\bar{n}_{a,eq}}{\bar{n}_{a,eq}}$ in existence, which can overcome the problem of the OS section steering mechanism changing at low power levels and producing deviation in the power curve. Of course if the CDH section ratio is too small, insufficient to overcome the change in the OS section steering mechanism, the laser will also produce deviation in the power curve at low power levels, since the power level that manifests deviation and the ratio occupied by the CDH section are related. The complex three-dimensional situation can be treated this way by simplifying it into a two-dimensional model. In summary, by adjusting the cavity-length ratio of the CDH and OS sections the strength of the built-in waveguide and the power level that manifests deviation in the power curve can be conveniently adjusted, which is easy to realize technologically.

The Chongqing Institute of Optoelectronic Technology's Yang Liansheng [2799 6647 3932], Hu Enzhi [7579 1869 1807], etc. comrades participated in the experimental work, and Chief Engineer Zhang Renjun [1728 0088 0689] gave enthusiastic support. Guo Changzhi [6753 7022 1807], teacher at Beijing University, gave extremely great encouragement to the work and concrete guidance in the theoretical analysis. For this we all express our gratitude.

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APPLIED SCIENCES

OUTPUT POWER EQUATION AND NUMERICAL INTEGRATING METHOD OF POSITIVE-BRANCH UNSTABLE CONFOCAL RESONATOR

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 5, No 11, Nov 85 pp 986-991

[Article by Cheng Zuhai [4453 4371 3189] and Li Zaiguang [2621 0375 0342], Laser Institute, Huazhong University of Science and Technology, and He Xuhui [0149 3563 6540], Department of Physics, National Defence Institute of Science and Technology, Wuhan: "Output Power Equation and Numerical Integrating Method of a Positive-branch Unstable Confocal Resonator"]

[Text] Text of English Abstract: The output power equation of a positive-branch unstable confocal resonator was deduced by using the numerical integrating method and dividing the resonator to two regions. The numerical results of this equation are in good agreement with experimental data.

I. Introduction

The unstable resonator has been widely used in high power lasers for its large hengmu [2897 2875 transverse mode?] volume and excellent quality of its output beam. Research on unstable resonators has generally focused on analysis of the oscillation mode in the chamber and research on its output characteristics has rarely been reported, because there are great difficulties in mathematics in solving fresnel diffraction integral equations which will satisfy the self-consistent field within the chamber. This paper proceeds from the characteristics of positive-branch confocal unstable resonator oscillations, divides the oscillation optical field within the chamber into two regions, one in which there are plane waves and spherical waves overlapping and one in which there are only plane waves, and employing electromagnetic field theory of optical resonance chambers, uses the hypotheses of paraxial approximation and uniform gain distribution and deduces a mathematical equation of output power by the zone integration method. Carrying out numerical computations one a PDP-11/70 computer using this equation, we obtained theoretical computations results which fit the experimental data. The outstanding advantages of using this zone integration method are that it saves computer time and reduces the volume of computations, it has practical value for computations of positive-branch confocal unstable resonator output and efficiency and for correctly selecting

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optical chamber parameters. The positive-beam confocal resonator designed on the basis of the computational results on an HGL-84 type 5kW CO_2 laser obtained satisfactory results of a basic mode output power of 3.8 kW, and electron optical conversion efficiency reached 9.8 percent.

II. Theoretical Deduction of Output Power Equation

As illustrated in Figure 1, the positive-beam confocal unstable resonator's pair of self-reproducing modes are, respectively, a rightward propagated spherical wave with point of origin at virtual confocal point O and a leftward propagated plane wave with point of origin at an infinitely remote location. Their wave vectors are expressed as k_1 and k_2, respectively. When the resonance field in the chamber is axially symmetrical, the compound amplitudes of the spherical wave and the plane wave respectively are:

$$E_1(z, r, t) = \frac{g(z, r, t)}{\sqrt{z^2+r^2}} \exp\left(ik\sqrt{z^2+r^2} - i\omega t\right), \tag{1}$$

$$E_2(z, r, t) = f(z, r, t)\exp[-i(kz+\phi) - i\omega t], \tag{2}$$

in which, $k = |k_1| = |k_2| = \frac{2\pi}{\lambda}$, $g(z, r, t)/\sqrt{z^2+r^2}$, $f(z, r, t)$ are the amplitude functions of the spherical wave and the plane wave, respectively, and is the initial phase of the plane wave.

The overall optical field E within the chamber

$$E(z, r, t) = E_1(z, r, t) + E_2(z, r, t)$$
$$= \left\{\frac{g(z, r, t)}{\sqrt{z^2+r^2}} \exp\left(ik\sqrt{z^2+r^2}\right) + f(z, r, t)\exp[-i(kz+\phi)]\right\}\exp(-i\omega t), \tag{3}$$

is the overlapping of the two waves.

In the coordinate system illustrated in Figure 1, the curved surface equations of lenses M_1 and M_2 are expressed as

$$\begin{cases} z = \sqrt{4(d+L)^2 - r^2} - (d+L), & (4) \\ z = \sqrt{4d^2 - r^2} - d, & (5) \end{cases}$$

According to standing wave conditions, the field intensity of the lens surface at M_1 and M_2 is zero, and taking Eqs. (4) and (5) into consideration, under paraxial approximation conditions:

$$\begin{cases} 4d^2 - r^2 \approx 4d^2, \\ 4(d+L)^2 - r^2 = 4(d+L)^2 \end{cases}$$

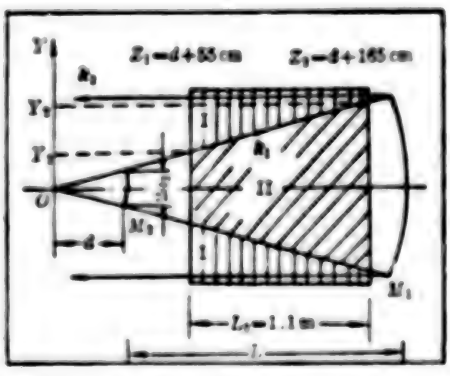


Figure 1. Divided regions and propagating waves in a positive-branch confocal unstable resonator

I: plane wave only;
II: both spherical and plane waves

we can find the relationship between phase and the amplitude of the spherical wave and the plane wave which satisfies:

$$\begin{cases} g(d+L, r, t) = -f(d+L, r, t) \\ \qquad\qquad \times (d+L), \\ g(d, r, t) = -f(d, r, t) \cdot d, \\ \phi = -2k(L+d). \end{cases} \tag{6}$$

Taking Eq. (8) into consideration, when z>d, equation (3) can be rewritten:

$$E(z, r, t) = \left\{ \frac{g(z, r, t)}{z} \exp\left[ik\left(z + \frac{r^2}{2z}\right)\right] + f(z, r, t)\exp[-ik(z-2d-2L)] \right\} \exp(-i\omega t). \tag{9}$$

In a gain medium, the general form wave equation can be expressed as [1]:

$$\nabla^2 E = c^{-2} \frac{\partial^2 E}{\partial t^2} - c^{-1} G \frac{\partial E}{\partial t}, \tag{10}$$

in which c is the speed of light, G is the gain coefficient of the laser's working medium.

Ignoring the influence of the diffraction amplitude distribution, after lengthy mathematical deductions we obtained the field distribution given for Eq. (9)

$$\begin{cases} \frac{\partial g}{\partial z} = -\frac{1}{2} G g, & (11) \\ \frac{\partial f}{\partial z} = \frac{1}{2} G f. & (12) \end{cases}$$

The matrix form for the above equations is:

$$\begin{pmatrix} \frac{\partial g}{\partial z} & \frac{1}{2} g \\ \frac{\partial f}{\partial z} & -\frac{1}{2} f \end{pmatrix} \begin{pmatrix} 1 \\ G \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \tag{13}$$

i.e.,

$$\frac{\partial f}{\partial z} g + \frac{\partial g}{\partial z} f = 0. \tag{14}$$

the original function form is:

$$f(z, r) \cdot g(z, r) = c(r). \tag{15}$$

Introducing functions $\theta(z)$, $f_0(r)$, and letting them satisfy:

$$\begin{cases} f(z, r) = f_0 \exp[\theta(z)], & (16) \\ \theta(d+L) = 0. & (17) \end{cases}$$

From Eqs. (6), (7), (15) and (16) we get

$$\begin{cases} c(r) = -(d+L) \cdot f_0^2(r), & (18) \\ c(r) = -d \cdot f_0^2(r) \exp[2\theta(r)], & (19) \\ \frac{L+d}{d} = \exp[2\theta(d)]. & (20) \end{cases}$$

Note the geometrical magnification $M = \frac{L+d}{d}$, the positive-beam confocal unstable resonator, therefore Eq. (2) can be changed to:

$$\frac{1}{2} \ln M = \theta(d). \quad (21)$$

Substituting Eqs. (16) and (18) in Eq. (15), we get:

$$g(z, r) = -(d+L) f_0(r) \exp[-\theta(z)]. \quad (22)$$

In the HGL-84 cross-flow electron excitation CO_2 laser which we studied, the gas pressure was above 90 Torr, the gain coefficient G of the medium can be expressed as:

$$G = \frac{G_0}{1 + I/I_s}, \quad (23)$$

in which I is the light intensity, I_s is the saturation light intensity, and G_0 is the small signal gain coefficient.

For ease of analysis, we divided the resonance chamber into regions I and II. From Figure 1 it can be seen that in region II there was coexistence of plane wave f(z,r) and spherical wave g(z,r), while in region I there was only plane wave f(z,r). Clearly, the oscillating light intensity of regions I and II can be expressed respectively as:

$$\begin{cases} I_1(z, r) = f^2(z, r), & (24) \\ I_2(z, r) = f^2(z, r) + \frac{1}{s^2} g^2(z, r). & (25) \end{cases}$$

Taking into account Eqs. (12), (23), and (24), the oscillating light intensity in region I can be expressed as

$$\frac{\partial I_1(z, r)}{\partial z} = \frac{I_1(z, r) G_0}{1 + \frac{I_2(z, r)}{I_s}}. \quad (26)$$

Solving this equation we can both obtain the light intensity on the emergent cross-section of the positive-beam confocal unstable resonator and also find the laser output power. However, Eq. (26) can only be solved under given boundary conditions of a common I and II boundary. Thus it is necessary first of all to find the plane wave amplitude function f(z,r) in region II.

The equation in region II can be obtained from Eqs. (12), (23), and (25):

$$\frac{\partial f(z,r)}{\partial z}=\frac{1}{2}G_0\left[1+\frac{f^2(z,r)+z^{-2}g^2(z,r)}{I_s}\right]^{-2}\cdot f(z,r). \tag{27}$$

Under paraxial approximation conditions, let $\xi=\frac{z}{L}$, take into account $\frac{z}{L+d}=\frac{z}{L}\left(1-\frac{1}{M}\right)$, then the above equation can be further rewritten:

$$\frac{d\theta(\xi)}{d\xi}=\frac{1}{2}G_0L\Big/\left\{1+\frac{f_0^2}{I_s}\left[e^{2\alpha(\xi)}+\frac{1}{\xi^2\left(1-\frac{1}{M}\right)^2}e^{-2\alpha(\xi)}\right]\right\}. \tag{28}$$

The above question is a first order differential equation which contains the special specific coefficient f_0, and must have two boundary condition equations (16) and (21) to be solved. After parameter conversion, equation (26) becomes

$$\frac{\partial I_2(\xi,r)}{\partial\xi}=I_2(\xi,r)\cdot L\cdot G_0\Big/\left[1+\frac{I_2(\xi,r)}{I_s}\right]. \tag{29}$$

Noting that $J_1=I_1/I_s$, the above equation becomes:

$$\frac{\partial J_2(\xi,r)}{\partial\xi}=J_2(\xi,r)\frac{G_0L}{1+J_2(\xi,r)}. \tag{30}$$

The boundary conditions of Eq. (30) can be given in the form f(z,r) after solution of Eq. (28) through conversion of Eq. (16). After the solution $J_1(\xi,r)$ of Eq. (30) is found, the output power equation of the positive-branch confocal unstable resonator is as follows:

$$P_{out}=2\pi I_s\int_{a_1}^{a_2}dr\cdot r\cdot J_2\left(\xi-\frac{d}{L},r\right). \tag{31}$$

III. Computation Method and Results

The key to solving the positive-branch confocal unstable resonator output power Eq. (31) is solving Eq. (28). But Eq. (28) is a first order non-linear ordinary differential equation with a very high degree of non-linearity and is very difficult to find an analytic solution. We used the fourth order Runge-Kutta method to carry out the numerical computations but before computing, we first used a computer search method to compute a series of $\theta(z_2/L)$ f_0, to make it close to $\frac{1}{2}\ln(M)$, and when we reached a predetermined precision, found the specific constant f_0 and solving Eq. (28) could obtain $\theta(\xi)$, making the conversion of equation (16) for the $\theta(\xi)$ already found, converting it to function f (z), i.e., carry out numerical computation of output power equation (31).

From Figure 1 it can be seen that in regions I and II, when $\xi<z_2/L$ or $\xi>z_1/L$ the medium gain is zero, but when $a_2<r<r_2-a_2\frac{z_2}{L}(M-1)$ we have

$$J_2(\xi-d/L,\ r)-J_2(\xi,\ r)-[f_0e^{\alpha(r)}]^2/I_s-Mf_0^2/I_{s0} \tag{32}$$

When $Ma_2>r>r_2-a_2\cdot\frac{z_2}{L}(M-1)$ we have

$$J_2(\xi-d/L,\ r)-J_2(z_2/L,\ r_2). \tag{33}$$

Taking the above conditions into consideration, Eq. (31) can finally be rewritten

$$P_{out}-2\pi I_s\left[\int_{a_2}^{r_1}+\int_{r_1}^{r_2}+\int_{r_2}^{Ma_2}\right]dr\cdot r\cdot J_2(\xi-d/L,\ r)$$
$$-2\pi I_s\left[\frac{r_1^2-a_2^2}{2}Mf_0^2/I_s+\int_{r_1}^{r_2}dr\cdot r\cdot J_2(\xi-d/L,\ r)+\frac{(Ma_2)^2-r_2^2}{2}J_2(z_2/L,\ r_2)\right]. \tag{34}$$

Using compound hualupushen [0553 3764 2528 3932] formula to carry out numerical integration on the integral terms of Eq. (34) in $r\in[r_1,r_2]$ region, numerical computation of the efficiency and output power of any positive-branch confocal unstable resonator can be carried out. Figure 2 corresponds to the two types positive-branch confocal unstable resonator structures of HGL-84 type transverse flow electron excitation CO_2 laser, in a chamber 2m long, with output coupled lens opening diameters a_2=25mm, M=1.67 and 1.4, corresponding to the average gain distribution pattern illustrated in Figure 3, the theoretical computation curve of the output characteristics of the two experimental unstable resonator obtained using equation (34).

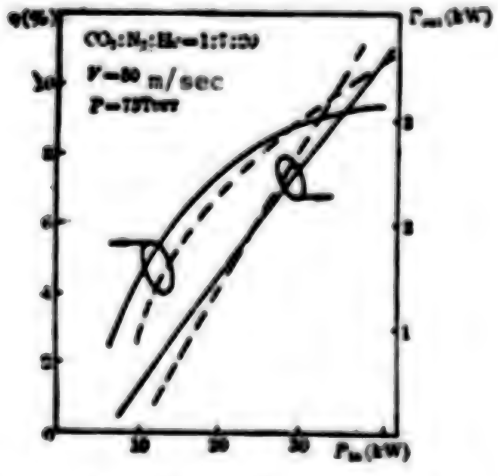


Figure 2. Theoretical curves of the output characteristics of the unstable confocal resonator used in experiments (lines: M = 1.07; dots: M = 1.4)

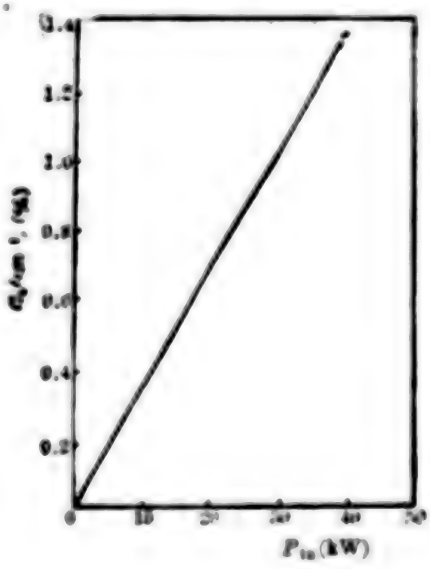
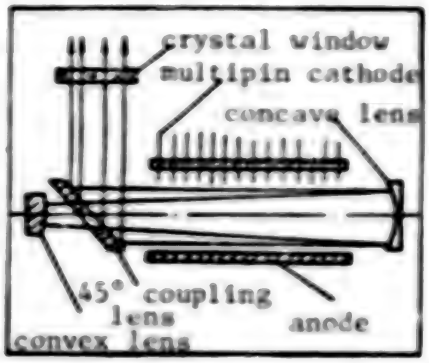


Figure 3. Small signal gain G_0 versus imput power P_{in} of a model HGL-84 CO_2 laser

IV. Comparison of Theoretical and Experimental Data

Experimental researches on output characteristics of an HGL-84 transverse flow CO_2 laser using the confocal unstable resonator structure illustrated in Figure 4. Typical optical chamber parameters of the experimental chamber were:

Figure 4. Schematic diagram of the confocal unstable resonator



Chamber length L=2m, inner diameter of the 45° coupled output lens d_2=25mm, the radii R_2 and R_1 of the convex lens and the concave lens curvature satisfied the confocal condition of $R_1-R_2=2L$, so that its geometrical magnification $M=R_1/R_2$ satisfies this chamber's equivalent Fresnel number: $N_{eq}=\frac{M-1}{2}\cdot\frac{a_2^2}{\lambda L}$ is the semi odd number condition which is favorable for selecting the transverse mode.[2]

Figures 5(a) and (5) are, comparisons of the theoretical computation and experimental data curves of efficiency and output power of the experimental resonator with, respectively, M=1.4 and M=1.67 positive-branch confocal unstable resonators under conditions of a gaseous flow velocity of 50m/sec, an operating gas pressure of 90 Torr, with a gas mixture ratio of $CO_2:N_2:He=1:7:20$.

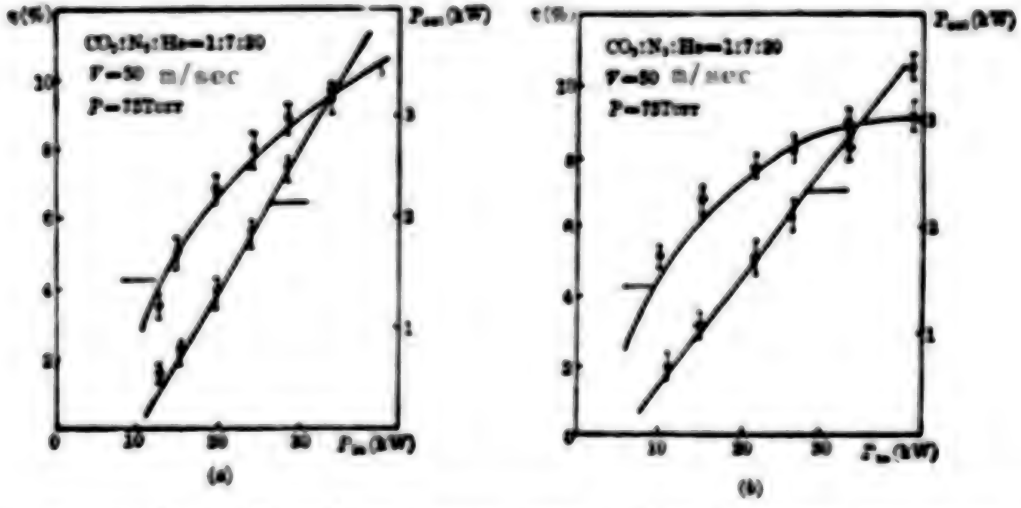


Figure 5. Theoretical (lines) and experimental (dots) output characteristics of the confocal unstable resonator

(a) M=1.4; (b) M=1.67

From Figure 5 it can be seen that the output characteristics of the positive-branch confocal unstable resonator computed using Eq. (34) can fit fairly well with the experimental results. It can be seen that using positive-branch confocal unstable resonator output power Eq. (31) derived from zone integration method has theoretical and practical value, especially for rational selection of optical chamber parameters and provides a reliable mathematical basis.

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APPLIED SCIENCES

CHARACTERISTIC OF VANE-LOADED HELIX SLOW-WAVE STRUCTURE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11, No 5, Sep 83 pp 23-32

[Article by Chen Qingyou [7115 1987 2589], Beijing Vacuum Electron Devices Research Institute; received May 1982, revised and finalized in December of the same year.]

[Text] English Abstract: Based on the existing vane-loaded helix slow-wave structure, a theoretical analytic model is proposed, in which the space between the helix and metallic barrel is fully filled up with dielectric, and vanes, infinite in number and infinitely thin in thickness, are set along all over the inner wall of the barrel. By utilizing the matching method of regional electromagnetic field for individual regions, the electromagnetic field distribution in the space of three respective regions is found. And the dispersion equation, couple impedance and attenuation constant are then obtained.

This paper also discusses the propagation system of electromagnetic wave, with S being the cross section of any shape. A principle of stored energy equalization is derived from the above discussion. Then rods of any shape can be made equivalent to that of wedge shape and, thus, $\varepsilon_{e//}$ can be obtained through the equation of $\varepsilon_{e//}-1=a(\varepsilon_r-1)$. Being free from any supplementary conditions, this method of dielectric treatment may be generalized and applicable to all sorts of slow-wave structure supported by dielectric rods of any shape and nature. A series of practical slow-wave structures are designed according to the above model. The calculated values are found to be in good agreement with the measured values.

1. Introduction

The vane-loaded helix slow-wave structure has been actually applied in dual mode TWT and wideband high power TWT. Tubes with this structure have some excellent characteristics. In addition to preserving basically the unchanged 4:1 electron injection within the bandwidth and wave asynchronous parameters, the nonlinear characteristics within the wideband, the compression characteristics of saturation time and power, and the relative shape of gain curves at different injection currents all were improved. In addition, under certain conditions, loading is lighter compared to isotropic metallic screen loading and longitudinal line conductive screen loading; compared with the longitudinal line, it can suppress

fast wave transmission; compared with some special dielectric holding rod loading it is better suited to high power applications. Thus vane-loading is a good method for improving TWT performance.

As concerns the dispersion characteristics of vane-loaded helix slow-wave structure, there are many analytical articles [1-4], but most do not treat the dielectric rod. Although reference [4] uses the pure surface area equivalency method to treat the dielectric rod, it overlooks the difference in electromagnetic field between a gapped dielectric ring and ungapped dielectric ring. Moreover, the theoretical bases of the pure surface equivalency method is that the electromagnetic field of the space in which the dielectric is situated is evenly distributed which does not conform to reality.

The analysis in this paper is based on such an axially symetrical model, the region between the helix and the metallic barrel is filled with dielectric, in this region are placed in infinite number of longitudinal vanes of a certain diameter, infinitely thin, and having infinitely large conductivity (see Figure 1); in the region where the vanes are situated there is only an angular electric field. We considered overall the influence of the dielectric and the conductor and solved for the characteristics of vane-loaded helix structure. When solving ε_{ett} for the actual holding rod shape, we did our processing very strictly, proceeding from the principle of stored energy equality. The results of computations for dispersion characteristics conform to the results of wide-band measurements of different actual structures. This computational method not only can be used for vane-loaded structures, but also has universal significance for other metallic screen loading and dielectric rod loading of a section of any shape.

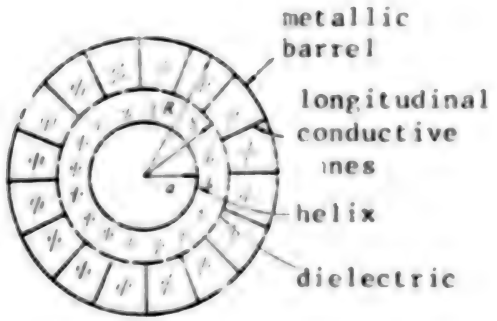

Figure 1 Analytical model

II. Theoretical Analysis

The analytical model of the actual vane-loaded helix slow-wave structure is illustrated in Figure 1. The entire structure is divided into three regions: region I, $0 \leq r \leq a$, $\varepsilon_1 \mu_1$; region II, $a \leq r \leq s$, $\varepsilon_2 \mu_2$ region III, $s \leq r \leq R$, $\varepsilon_3 \mu_3$, ε_i, μ_i . ($i=1,2,3$) are the dielectric constant and magnetic

inductivity of the dielectric in the three regions respectively; r is the columnar coordinate radius; a is the radius of the conducting surface spiral; s is the radius of the top of the vane; R is the inner radius of the barrel. Using the conducting surface spiral model considers only the electromagnetic field in the regions of the minimum times model (n=0) as:

$$
\begin{aligned}
E_{z,i} &= [A_i I_0(\gamma_i r) + B_i K_0(\gamma_i r)] \exp j(\omega t - \beta_i z) \\
H_{z,i} &= [C_i I_0(\gamma_i r) + D_i K_0(\gamma_i r)] \exp j(\omega t - \beta_i z) \\
E_{r,i} &= \frac{j\beta_i}{\gamma_i^2} \frac{\partial E_{z,i}}{\partial r}, \quad i = 1, 2, 3 \\
E_{\theta,i} &= -\frac{j\omega\mu_i}{\gamma_i^2} \frac{\partial H_{z,i}}{\partial r} \\
H_{r,i} &= \frac{j\beta_i}{\gamma_i^2} \frac{\partial H_{z,i}}{\partial r} \\
H_{\theta,i} &= \frac{j\omega\varepsilon_i}{\gamma_i^2} \frac{\partial E_{z,i}}{\partial r}
\end{aligned}
\qquad (1)
$$

in which γ is the radial phase constant, $\gamma_i^2 = \beta_i^2 - k_i^2$; k_i is the free space phase constant, $k_i^2 = \omega^2 \mu_i \varepsilon_i$; β is the axial phase constant; $K_i(\gamma r)$ is the Bessel function of the second kind of order i of the zongliang [1350 6852] as γr . Since $\beta \gg k_i$, we know that $\gamma_1 = \gamma_2 = \gamma_3 = \gamma$.

The boundary conditions of the regions are: when r=R, $E_\tau = 0$; when r=s, $E_z = 0$, and H_z / E_θ continuously; when r=a,

$$E_{z1} = E_{z2}, \quad E_{\theta 1} = E_{\theta 2}, \quad E_{z1} \sin\psi + E_{\theta 1} \cos\psi = 0, \quad H_{z1} \sin\psi + H_{\theta 1} \cos\psi = H_{z2} \sin\psi + H_{\theta 2} \cos\psi .$$

The natural boundary conditions are: $B_1 = D_1 = 0$.

The solution to the electromagnetic field distribution for the region is:

$$
\left.
\begin{aligned}
E_{z1} &= A I_0(\gamma r) \\
H_{\theta 1} &= -A \frac{j\gamma}{\omega\mu_1 \operatorname{ctg}\psi} \frac{I_{20}}{I_{10}} I_0(\gamma r) \\
E_{r1} &= A \frac{j\beta_1}{\gamma} I_1(\gamma r) \\
E_{\theta 1} &= -A \frac{I_{20}}{I_{10} \operatorname{ctg}\psi} I_1(\gamma r) \\
H_{r1} &= A \frac{\beta_1}{\omega\mu_1 \operatorname{ctg}\psi} \frac{I_{20}}{I_{10}} I_1(\gamma r) \\
H_{\theta 1} &= A \frac{j\omega\varepsilon_1}{\gamma} I_1(\gamma r)
\end{aligned}
\right\} \qquad (2a)
$$

$$E_{r2}=A\left[I_0(\gamma r)-\frac{I_{0s}}{K_{0s}}K_0(\gamma r)\right]\Big/\left(1-\frac{I_{0s}K_{0a}}{K_{0s}I_{0a}}\right),$$

$$H_{z2}=-A\frac{j\gamma}{\omega\mu_2 \operatorname{ctg}\psi}\cdot\frac{I_{0a}}{I_{1a}}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_0(\gamma r)+\frac{I_{1R}}{K_{1R}}K_0(\gamma r)\right]$$

$$E_{r2}=A\frac{j\beta_2}{\gamma}\left[1\Big/\left(1-\frac{I_{0s}K_{0a}}{K_{0s}I_{0a}}\right)\right]\left[I_1(\gamma r)+\frac{I_{0s}}{K_{0s}}K_1(\gamma r)\right]$$

$$E_{\varphi 2}=-A\frac{I_{0a}}{I_{1a}\operatorname{ctg}\psi}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_1(\gamma r)-\frac{I_{1R}}{K_{1R}}K_1(\gamma r)\right]$$

$$H_{r2}=A\frac{\beta_2}{\omega\mu_2\operatorname{ctg}\psi}\cdot\frac{I_{0a}}{I_{0a}}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_1(\gamma r)-\frac{I_{1R}}{K_{1R}}K_1(\gamma r)\right]$$

$$H_{\varphi 2}=A\frac{j\omega\varepsilon_2}{\gamma}\left[1\Big/\left(1-\frac{I_{0s}K_{0a}}{K_{0s}I_{0a}}\right)\right]\left[I_1(\gamma r)+\frac{I_{0s}}{K_{0s}}K_1(\gamma r)\right] \qquad (2b)$$

$$E_{z3}=0$$

$$H_{z3}=-A\frac{j\gamma}{\omega\mu_3\operatorname{ctg}\psi}\cdot\frac{I_{0a}}{I_{1a}}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_0(\gamma r)+\frac{I_{1R}}{K_{1R}}K_0(\gamma r)\right]$$

$$E_{r3}=0$$

$$E_{\varphi 3}=-A\frac{\mu_3}{\mu_2\operatorname{ctg}\psi}\cdot\frac{I_{0a}}{I_{1a}}\left[1\Big/\left(1-\frac{I_{1R}K_{1a}}{K_{1R}I_{1a}}\right)\right]\left[I_1(\gamma r)-\frac{I_{1R}}{K_{1R}}K_1(\gamma r)\right] \qquad (2c)$$

in which $I_i(\gamma a)$ is the Bessel function of the first kind of order i of the independent variable γa, $I_{0a}=I_0(\gamma a)$, $I_{1a}=I_1(\gamma a)$, $I_{0s}=I_0(\gamma s)$, $I_{1R}=I_1(\gamma R)$, $K_{0s}=K_0(\gamma s)$, $K_{1R}=K_1(\gamma R)$

The solution to the dispersion equation is:

$$\left(\frac{k_1}{\gamma}\operatorname{ctg}\psi\right)^2=\left[I_{0a}^2-\frac{\mu_1}{\mu_2}I_{0a}I_{1a}\frac{G_{III}(\gamma a,\gamma R)}{G_{II}(\gamma a,\gamma R)}\right]\Big/\left[I_{1a}^2-\frac{\varepsilon_1}{\varepsilon_2}I_{0a}I_{1a}\frac{G_{IV}(\gamma a,\gamma s)}{G_{III}(\gamma a,\gamma s)}\right] \qquad (3)$$

in which $G_{III}(\gamma a,\gamma R)=I_{0a}K_{1R}+I_{1R}K_{0a}$; $G_{II}(\gamma a,\gamma R)=I_{1a}K_{1R}-I_{1R}K_{1a}$; $G_{IV}(\gamma a,\gamma s)=I_{1a}K_{0s}+I_{0s}K_{1a}$; $G_{III}(\gamma a,\gamma s)=I_{0a}K_{0s}-I_{0s}K_{0a}$

$\operatorname{ctg}\psi=\frac{2\pi a}{p}$, where a is the average radius of the helix, and p is the thread pitch.

If there are no vanes, s=R, then Eq. (3) changes to

$$\left(\frac{k_1}{\gamma}\operatorname{ctg}\psi\right)^2=\frac{I_{0a}^2-\frac{\mu_1}{\mu_2}I_{0a}I_{1a}\frac{G_{III}}{G_{II}}}{I_{1a}^2-\frac{\varepsilon_1}{\varepsilon_2}I_{0a}I_{1a}\frac{G_{IV}}{G_{III}}} \qquad (4)$$

in which $G_{III}=I_{0a}K_{1R}+I_{1R}K_{0a}$; $G_{II}=I_{1a}K_{1R}-I_{1R}K_{1a}$; $G_{IV}=I_{1a}K_{0R}+I_{0R}K_{1a}$; $G_{III}=I_{0a}K_{0R}-I_{0R}K_{0a}$.
This is the result of Gilmour et al.[5]

Finding the coupled impedance was essentially solving the system's overall power flow P_T. Finding the power flow of the regions as delineated in Figure 1, and using Eq. (2), we get:

$$P_T = P_1 + P_2 + P_3 = \frac{\pi A^2 \beta_1 k_1 a^2}{2\gamma^2 \sqrt{\mu_1/\varepsilon_1}} \cdot L_T \tag{5}$$

in which $L_T = M(\gamma a)\left[1 + \frac{\gamma^2}{k_1^2 \operatorname{ctg}^2 \psi} \frac{I_{0a}^2}{I_{1a}^2}\right] + \frac{\beta_2}{\beta_1} \frac{\varepsilon_2}{\varepsilon_1} I_{0a}^2 \left[\left(\frac{s^2}{a^2} M(\gamma s) - M(\gamma a)\right)\left(\frac{K_{0s}^2}{G_{0s,0s}^2}\right.\right.$

$$+\left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2 \frac{K_{1R}^2}{G_{1s,1R}^2}\Big) + 2\left(\frac{s^2}{a^2} P(\gamma s) - P(\gamma a)\right)\left(\frac{I_{0s} K_{0s}}{G_{0s,0s}^2}\right.$$

$$-\left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2 \frac{I_{1R} K_{1R}}{G_{1s,1R}^2}\Big) + \left(\frac{s^2}{a^2} N(\gamma s) - N(\gamma a)\right)\left(\frac{I_{0s}^2}{G_{0s,0s}^2}\right.$$

$$+\left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2 \frac{I_{1R}^2}{G_{1s,1R}^2}\Big)\Big] + \frac{\beta_2}{\beta_1} \frac{\varepsilon_2}{\varepsilon_1} \frac{s^2}{a^2}$$

$$\cdot I_{0a}^2 \left(\frac{\mu_2}{\mu_1}\right)^2 \left[\left(\frac{R^2}{s^2} M(\gamma R) - M(\gamma s)\right) \frac{K_{1R}^2}{G_{1s,1R}^2} \left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2\right.$$

$$-2\left(\frac{R^2}{s^2} P(\gamma R) - P(\gamma s)\right) \frac{I_{1R} K_{1R}}{G_{1s,1R}^2} \left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2 + \left(\frac{R^2}{s^2}\right.$$

$$\left.\left.\cdot N(\gamma R) - N(\gamma s)\right) \frac{I_{1R}^2}{G_{1s,1R}^2} \left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2\right]$$

$G_{0s,0s} = I_{0s} K_{0s} - I_{0s} K_{0s}$; $G_{1s,1R} = I_{1s} K_{1R} - I_{1R} K_{1s}$; $M(x) = I_1^2(x) - I_0(x) I_2(x)$; $N(x) = K_1^2(x) - K_0(x) K_2(x)$; $P(x) = I_1(x) K_1(x) + I_0(x) K_2(x)$.

The impedance parameters are

$$\left(\frac{E_{s0}^2}{\beta_1^2 P_T}\right)^{1/3} = \left(\frac{\gamma}{\beta_1}\right)^{4/3} \left(\frac{\beta_1}{k_1}\right)^{1/3} \left[\frac{(\gamma a)^2}{240} L_T\right]^{-1/3} \tag{6}$$

The average coupled impedance of the electron injection regions is

$$\bar{K}_{\perp} = \frac{1}{2}\left(\frac{\beta_1}{k_1}\right)\left(\frac{\gamma}{\beta_1}\right)^4 \left[I_0^2(\gamma r_e) - I_1^2(\gamma r_e)\right]\left[\frac{(\gamma a)^2}{240} L_T\right]^{-1} \tag{7}$$

in which r_e is the electron injection radius.

If there are no vanes, then $P_3 = 0$ and an expression P_T similar to Eq. (5), but the content of L_T in the equation is different.

$$P_T = \frac{\pi A^2 k_1 \beta_1 a^2}{2\gamma^2 \sqrt{\mu_1/\varepsilon_1}} L_T \tag{8}$$

in which

$$L_T = M(\gamma a)\left(1 + \frac{\gamma^2}{k_1^2 \operatorname{ctg}^2 \psi} \frac{I_{0a}^2}{I_{1a}^2}\right) + \frac{\beta_2}{\beta_1} \frac{\varepsilon_2}{\varepsilon_1} I_{0a}^2 \left[\left(\frac{R^2}{a^2} M(\gamma R)\right.\right.$$

$$\left.- M(\gamma a)\right)\left(\frac{K_{0R}^2}{G_{00}^2} + \left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2 \frac{K_{1R}^2}{G_{11}^2}\right) + 2\left(\frac{R^2}{a^2} P(\gamma R)\right.$$

$$\left.- P(\gamma a)\right)\left(\frac{I_{0R} K_{0R}}{G_{00}^2} - \left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2 \frac{I_{1R} K_{1R}}{G_{11}^2}\right) + \left(\frac{R^2}{a^2} N(\gamma R)\right.$$

$$\left.- N(\gamma a)\right)\left(\frac{I_{0R}^2}{G_{00}^2} + \left(\frac{\gamma}{k_2 \operatorname{ctg} \psi}\right)^2 \frac{I_{1R}^2}{G_{11}^2}\right)\Big]$$

The attenuation constant α is defined as: $\alpha = -\frac{1}{2P_T}\frac{dP_T}{dz}$. The rate of change axially in the total power flow of the electromagnetic wave transmitted along the axis of the system is equal to the power dissipated in section dz. Using the approximate boundary conditions of Leontovich and Eq. (2) we get:

$$\alpha = \frac{k_3 R_{s1}}{\beta_1 a\sqrt{\mu_2/\varepsilon_2}}\frac{I_{0e}^2}{L_T}\frac{\varepsilon_2}{\varepsilon_1}\left\{\left[\left(\frac{\varepsilon_1}{\varepsilon_2}\frac{I_{1e}}{I_{0e}}\right)^2+\left(\frac{\gamma^2}{k_1^2\operatorname{ctg}\psi}\right)^2\right.\right.$$
$$\left.\cdot\left(\frac{\varepsilon_1}{\varepsilon_2}\frac{I_{0e}}{I_{1e}}\right)^2+\left(\frac{G_{1e,0r}}{G_{0e,0r}}\right)^2+\left(\frac{\gamma^2}{k_1^2\operatorname{ctg}\psi}\right)^2\left(\frac{G_{0e,1R}}{G_{1e,1R}}\right)^2\right]$$
$$+\frac{R_{s2}}{R_{s1}}\frac{s}{a}\left[\left(\frac{1}{\gamma_r}\right)^2\left(\frac{1}{G_{0e,0r}}\right)^2+2\left(\frac{\gamma^2}{k_1^2\operatorname{ctg}\psi}\right)^2\left(\frac{G_{0r,1R}}{G_{1e,1R}}\right)^2\right]$$
$$\left.+\frac{R_{s3}}{R_{s1}}\frac{R}{a}\left(\frac{1}{\gamma R}\right)^2\left(\frac{1}{G_{1e,1R}}\right)^2\left(\frac{\gamma^2}{k_1^2\operatorname{ctg}\psi}\right)^2\right\} \qquad (9)$$

where L_T in the equation and Eq. (5) are identical. R_{s1}, R_{s2}, and R_{s3} are the single phase length high frequency resistance of the helix, the vane top surface, and the barrel respectively. If there are no vanes, then Eq. (9) can be changed to

$$\alpha = \frac{k_3 R_{s1}}{\beta_1 a\sqrt{\mu_2/\varepsilon_2}}\frac{I_{0e}^2}{L_T}\frac{\varepsilon_2}{\varepsilon_1}\left\{\left[\left(\frac{\varepsilon_1}{\varepsilon_2}\frac{I_{1e}}{I_{0e}}\right)^2+\left(\frac{\gamma^2}{k_1^2\operatorname{ctg}\psi}\right)^2\left(\frac{\varepsilon_1}{\varepsilon_2}\frac{I_{0e}}{I_{1e}}\right)^2\right.\right.$$
$$\left.+\left(\frac{G_{11}}{G_{00}}\right)^2+\left(\frac{\gamma^2}{k_1^2\operatorname{ctg}\psi}\right)^2\left(\frac{G_{11}}{G_{11}}\right)^2\right]+\frac{R_{s3}}{R_{s1}}\frac{R}{a}\left(\frac{1}{\gamma R}\right)^2\frac{1}{G_{00}^2}$$
$$\left.+\left(\frac{\gamma^2}{k_1^2\operatorname{ctg}\psi}\right)^2\left(\frac{1}{\gamma R}\right)^2\frac{1}{G_{11}^2}\right\} \qquad (10)$$

L_T in the equation and Eq. (8) are identical.

III. Some Problems of Numerical Computations

The actual helix slow-wave structure is as illustrated in Figure 2. The computational formulas in the preceding section cannot be applied directly, but the equivalency dielectric constant $\varepsilon_{e,r}$ must be found from an actual structure.

First we discuss the general situation. Suppose an electromagnetic wave transmission system, section S is of any shape, place dielectric of section ΔS along the axis of this system, the section shape and dielectric characteristics are all arbitrary, then we can prove (see Appendix) that the system transmission constant placed in front of and behind the dielectric has the following relationship:

$$\beta - \beta_0 = \frac{\omega\int_{\Delta S}(\varepsilon-\varepsilon_0)E\,E_0^*\,dS}{c\int_S(E_0^*\times H+E\times H_0^*)e_z\,dS} \qquad (11)$$

the denominator represents the system's power flow, the numerator represents the change in stored energy after the dielectric is placed in the column of section ΔS.

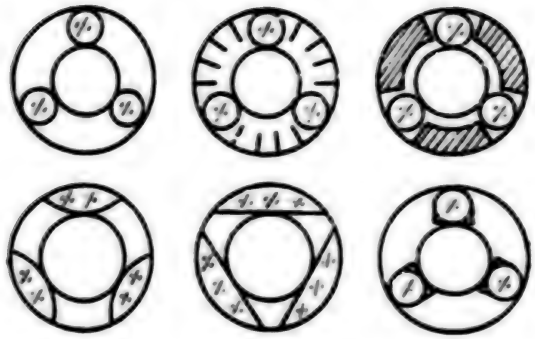

Figure 2. Actual helix slow-wave structure

For the actual vane-loaded structure (Figure 3), it was only necessary to consider circular rods of the part $B_2F_2D_2C_1F_0A_1$. We thought that with the phase constant of a vane-loaded structure of dielectric of the shape $A_2F_2C_2C_1F_0A_1$ as β_0, the system phase constant after placing a dielectric of section S_2 as β_2, and the system phase constant after placing a dielectric of section S_1 as β_1, then the condition $\beta_2=\beta_1$ which we could get according to Eq. (11) was the stored energy equality of dielectric S_1 and S_2, i.e.,

$$\int_{s_1} E_1 E_1^* dS = \int_{s_2} E_1 E_1^* dS \qquad (12)$$

Thus, the dielectric rod of the shape $B_2F_2D_2C_1F_0A_1$ can be equivalent to the fan-shaped rod which has angle θ, then we can solve

$$\varepsilon_{\pi} - 1 = (\varepsilon_r - 1)\frac{N\theta}{2\pi} \qquad (13)$$

N in the equation is the number of dielectric rods.

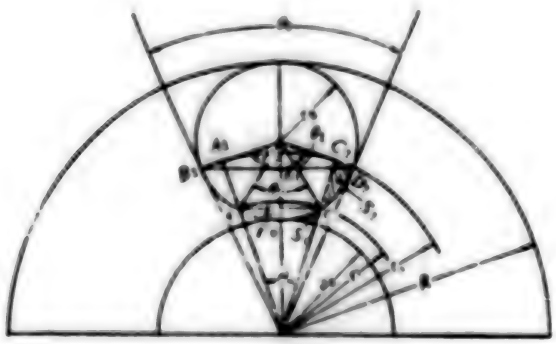

Figure 3. Actual vane-loaded structure

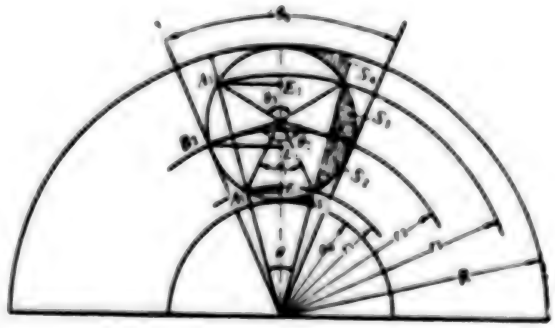

Figure 4. Actual non-vaned structure

From the geometrical diagram we can get

$$2S_1=\frac{1}{2}\theta(r_1^2-a_0^2)-\left[\frac{1}{2}(\theta r_1^2+\theta_1 r_0^2)-\overline{A_1E_1}(a_0+r_0)\right] \tag{14}$$

in which $\theta=2\sin^{-1}\frac{\overline{A_1E_1}}{r_1}$, $\theta_1=2\sin^{-1}\frac{\overline{A_1E_1}}{r_0}$, $A_1E_1=\frac{1}{2(r_0+a_0)}\sqrt{(r_1^2-a_0^2)(R^2-r_1^2)}$

$$2S_2=\frac{1}{2}(\theta_0 r_2^2+\theta_2 r_0^2)-\overline{B_2E_2}(a_0+r_0)-(r_2^2-a_0^2)\frac{\theta}{2}-2S_1 \tag{15}$$

in which $\overline{B_2E_2}=\frac{1}{2(r_0+a_0)}\sqrt{(r_2^2-a_0^2)(R^2-r_2^2)}$, $\theta_0=2\sin^{-1}\frac{\overline{B_2E_2}}{r_0}$, $\theta_2=2\sin^{-1}\frac{\overline{B_2E_2}}{r_0}$

From Eq. (2) we can find the average field strength of the two regions $a_0\leqslant r\leqslant r_1$ 及 $r_1\leqslant r\leqslant r_2$,

$$\left.\begin{aligned}
\overline{E_z(\mathrm{I})}&=\frac{1}{\gamma^2(r_1^2-a_0^2)}\left[2A\Big/\left(1-\frac{I_{01}K_{02}}{K_{01}I_{02}}\right)\right]\left\{[\gamma r_1 I_1(\gamma r_1)\right.\\
&\left.-\gamma a_0\cdot I_1(\gamma a_0)]-\frac{I_{01}}{K_{01}}[\gamma r_1 K_1(\gamma r_1)-\gamma a_0 K_1(\gamma a_0)]\right\}\\
\overline{E_z(\mathrm{II})}&=\frac{1}{\gamma^2(r_2^2-r_1^2)}\left[2A\Big/\left(1-\frac{I_{01}K_{02}}{K_{01}I_{02}}\right)\right]\left\{[\gamma r_2 I_1(\gamma r_2)\right.\\
&\left.-\gamma r_1\cdot I_1(\gamma r_1)]-\frac{I_{01}}{K_{01}}[\gamma r_2 K_1(\gamma r_2)-\gamma r_1 K_1(\gamma r_1)]\right\}
\end{aligned}\right\} \tag{16}$$

Solving Eqs. (12), (14), (15) and (16) together we can find θ.

For structures without vanes, we must consider the entire circular holding rod, which can be divided into four regions: $a_0\leqslant r\leqslant r_1$, $r_1\leqslant r\leqslant r_2$, $r_2\leqslant r\leqslant r_3$ and $r_3\leqslant r\leqslant R$ (Figure 4).

The average field strength of the regions respectively is:

$$\left.\begin{aligned}
\overline{E_z(\mathrm{I})}&=\frac{1}{\gamma^2(r_1^2-a_0^2)}\ \frac{2AI_{02}}{I_{01}K_{02}-K_{01}I_{02}}\{K_{02}[\gamma r_1 I_1(\gamma r_1)-\gamma a_0 I_1(\gamma a_0)]\\
&+I_{02}[\gamma r_1 K_1(\gamma r_1)-\gamma a_0 K_1(\gamma a_0)]\}\\
\overline{E_z(\mathrm{II})}&=\frac{1}{\gamma^2(r_2^2-r_1^2)}\ \frac{2AI_{02}}{I_{01}K_{02}-K_{01}I_{02}}\{K_{02}[\gamma r_2 I_1(\gamma r_2)-\gamma r_1 I_1(\gamma r_1)]\\
&+I_{02}[\gamma r_2 K_1(\gamma r_2)-\gamma r_1 K_1(\gamma r_1)]\}\\
\overline{E_z(\mathrm{III})}&=\frac{1}{\gamma^2(r_3^2-r_2^2)}\ \frac{2AI_{02}}{I_{01}K_{02}-K_{01}I_{02}}\{K_{02}[\gamma r_3 I_1(\gamma r_3)-\gamma r_2 I_1(\gamma r_2)]\\
&+I_{02}[\gamma r_3 K_1(\gamma r_3)-\gamma r_2 K_1(\gamma r_2)]\}\\
\overline{E_z(\mathrm{IV})}&=\frac{1}{\gamma^2(R^2-r_3^2)}\ \frac{2AI_{02}}{I_{01}K_{02}-K_{01}I_{02}}\{K_{02}[\gamma R I_1(\gamma R)-\gamma r_3 I_1(\gamma r_3)]\\
&+I_{02}[\gamma R K_1(\gamma R)-\gamma r_3 K_1(\gamma r_3)]\}
\end{aligned}\right\} \tag{17}$$

From the geometrical figure we can find:

$$2S_1=\frac{1}{2}\theta(r_1^2-a_0^2)-\left[\frac{1}{2}(\theta r_1^2+\theta_1 r_0^2)-\overline{A_1E_1}(a_0+r_0)\right] \tag{18}$$

in which, $\theta=2\sin^{-1}\frac{\overline{A_1E_1}}{r_1}$, $\theta_1=2\sin^{-1}\frac{\overline{A_1E_1}}{r_0}$, $\overline{A_1E_1}=\frac{1}{2(r_0+a_0)}\sqrt{(r_1^2-a_0^2)(R^2-r_1^2)}$

$$2S_2=\frac{1}{2}\pi(\theta_2 r_2^2+\theta_2 r_0^2)-\overline{B_2E_2}(a_0+r_0)-\frac{\theta}{2}(r_2^2-a_0^2)+2S_1 \tag{19}$$

in which $\overline{B_2E_2}=\frac{1}{2(r_0+a_0)}\sqrt{(r_2^2-a_0^2)(R^2-r_2^2)}$, $\theta_2=2\sin^{-1}\frac{\overline{B_2E_2}}{r_2}$, $\theta_2=2\sin^{-1}\frac{\overline{B_2E_2}}{r_0}$

$$2S_3=\pi r_3^2-\left[\frac{1}{2}(\theta_2 r_3^2+\theta_2 r_3^2)-\overline{B_2E_2}(r_0+a_0)\right]-\frac{1}{2}(R^2-r_3^2)+2S_4 \tag{20}$$

$$2S_4=\frac{1}{2}(R^2\theta-r_0^2\theta_4)-\overline{A_2E_2}(r_0+a_0) \tag{21}$$

in which $\overline{A_2E_2}=\frac{1}{2(r_0+a_0)}\sqrt{(r_3^2-a_0^2)(R^2-r_3^2)}$, $\theta_3=2\sin^{-1}\frac{\overline{A_2E_2}}{r_0}$, $\theta=2\sin^{-1}\frac{\overline{A_2E_2}}{r_3}$

$=2\sin^{-1}\frac{\overline{A_2E_2}}{r_3}$.

On the basis of the condition of stored energy equality, $2S_1\overline{E_0(\mathrm{I})^2}=2S_1\overline{E_0(\mathrm{II})^2}$ and $2S_3\overline{E_0(\mathrm{III})^2}=2S_4\overline{E_0(\mathrm{IV})^2}$, , i.e., we can find θ. In actual computations, one can discover that processing dielectric S_3 and S_4 is not really important, especially when γ_a is large (for example, $\gamma_a>1.5$) it can be omitted. When γ_a is relatively small, processing this term can be treated as a correction term.

The actual structures of the other shapes in Figure 2 can be processed according to the above described principles. It should be noted that the application of Eq. (11) is correct only when the disturbances to the system's electrical field caused by the medium is not great and this conforms to the actual situation.

IV. Comparison of Computational Results and Experimental Results

To check the computation method, we selected helixes of three transverse dimensions, which corresponded to the typical dimensions of 10, 5, 3, and 2 mm wave segments respectively. We obtained measurement data by using the cold measurement and hot measurement methods within the range of 2-16GHz. The experimental model includes: filament wound and belt wound helixes, the influence of dielectric loading (variation of dielectric material and the dielectric rod geometric dimensions), the influence of metallic screen loading (isotropic metallic screens, longitudinal conductive screen, vane-loading), influence of number of vanes and radius of vane tops, influence of industrial technology (cold elastic pressure, thermal expansion, flash welding, and diffusion welding). The experimental data was drawn from the same system, the same power source and the same voltage meter. Figures 5 and 6 give partial results (curve A represents the computational values of this paper, curve B represents the computational values of the surface equivalence method, the symbols xϕ° and • represent the experimental values).

Synthesizing the great quantity of computational results and test results we can reach the following conclusions:

1. Theory and experiment both show that as far as practical vane-loaded TWT are concerned, using a great number of vanes and a large s/a value makes it effective. Thus, the analytical model in this paper not only comes close to the actual structure, but also the computations are handy.

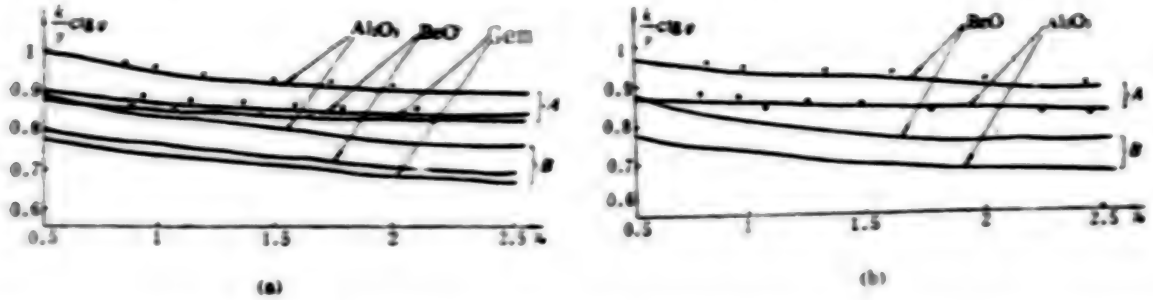

Figure 5. Comparison of computational and experimental results for non-vaned structures

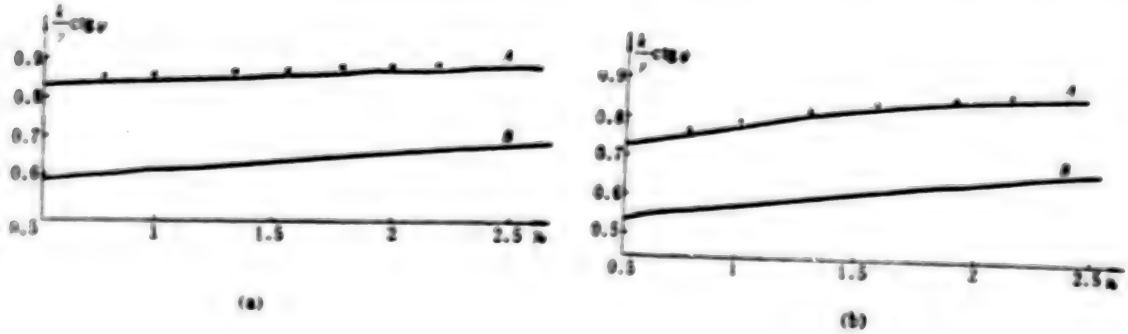

Figure 6. Comparison of computational and experimental results for vane-loaded structures

2. The characteristics of the actual slow-wave structure are determined by the space electromagnetic distribution of the structure. Using the concept of stored energy equality as a method for processing dielectric rods not only is theoretically strict, but the computational results also conform to actual measurements. There are no limitations on this method for dielectric performance and geometrical shape, thus there is universality. The ε_{eff} of a wedge-shaped rod substitutes for the dielectric ring's ε, formula $\varepsilon_{eff}-1=(\varepsilon-1)\,a$, $a=N\theta/2\pi$.

In terms of shape, it seems that a is an area ratio, but actually it is stored energy concept results obtained under special conditions. If these special case errors are seen as universal principles, then there are problems in introducing the concept of the pure area equivalency of the dielectric rod.

In this paper we were guided and helped by Professor Wu Hongshi [0702 7703 6624], comrades from our laboratory did a great deal of tube manufacturing work and we should like to express our thanks here.

Appendix

Discussing an electromagnetic wave transmission system of section S, if a dielectric of section ΔS is placed along the axial direction of the system (as in Figure 7) then the electromagnetic field of the system changes from E_0H_0 to EH. ε and μ are equation definitions from $B = \mu H$ and $D = \varepsilon E$.

Figure 7. Transmission system of S section

For isotropic dielectrics, ε is the scalar; for anisotropic dielectrics, ε is the bipolar tensor, $D_i = \sum_{k=1}^{3} \varepsilon_{ik} E_k$ for isotropic diamagnetic and paramagnetic bodies, μ is the scalar; for anisotropic ferromagnetic materials, μ is the second order tensor, $B_i = \sum_{k=1}^{3} \mu_{ik} H_k$. Only when the dielectric is placed in the region inside S can the Kronecker symbol δ_{ik} be used.

$B = \hat{\mu}'H$ $\quad \hat{\mu}'H$ representative component is the vector $\hat{\mu}'_{ik}H_k$

$D = \hat{\varepsilon}'E$ $\quad \hat{\varepsilon}'E$ representative component is the vector $\hat{\varepsilon}'_{ik}E_k$

In ΔS $\mu'_{ik} = \mu_{ik}$, $\varepsilon'_{ik} = \varepsilon_{ik}$; on $S - \Delta S$, $\mu'_{ik} = \varepsilon'_{ik} = \delta_{ik}$.

According to Maxwell's equation

$$\nabla \times E = -\frac{1}{c}\frac{\partial B}{\partial t}, \qquad \nabla \times H = \frac{1}{c}\frac{\partial D}{\partial t}$$

in a system which does not have dielectric ΔS placed in it,

$$E_0(x, y, z) = E_0(x, y)\exp j(\beta_0 z - \omega t), \quad H_0(x, y, z) = H_0(x, y)\exp j(\beta_0 z - \omega t),$$

thus we can get:

$$\nabla \times E_0(x, y) + j\beta_0 (e_z \times E_0(x, y)) = \frac{j\omega\mu_0}{c} H_0(x, y)$$

$$\nabla \times H_0(x, y) + j\beta_0 (e_z \times H_0(x, y)) = -\frac{j\omega\varepsilon_0}{c} E_0(x, y)$$

In a system after the dielectric ΔS is placed in it we can get:

$$\nabla \times E(x, y) + j\beta(e_z \times E(x, y)) = \frac{j\omega\hat{\mu}'}{c} H(x, y)$$

$$\nabla \times H(x, y) + j\beta(e_z \times H(x, y)) = -\frac{j\omega\hat{\varepsilon}'}{c} E(x, y)$$

$$\nabla \cdot (H \times E_0^*) + \nabla \cdot (H_0^* \times E) = j(\beta - \beta_0)(E_0^* \times H + E \times H_0^*) \cdot$$

$$\cdot e_z - \frac{j\omega}{c}[(\hat{\varepsilon}' - \varepsilon_0) E \cdot E_0^* + (\hat{\mu}' - \mu_0) H \cdot H_0^*]$$

Taking the volume integral and using Gauss's theorem

$$\oint_s (H\times E_0^*+H_0^*\times E)\cdot n\,dS=0$$

we get

$$\beta-\beta_0=\frac{\omega\int_{s_1}[(\hat{\varepsilon}-\varepsilon_0)E\cdot E_0^*+(\hat{\mu}-\mu_0)H\cdot H_0^*]\,dS}{c\int_s[E_0^*\times H+E\times H_0^*]\cdot e_z\,dS}$$

For isotropic non-magnetic dielectric rods it can be simplified to

$$\beta-\beta_0=\frac{\omega\int_{s_1}(\varepsilon-\varepsilon_0)E\cdot E_0^*\,d_1}{C\int_s(E_0^*\times H+E\times H_0^*)\cdot e_z\,dS}$$

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APPLIED SCIENCES

IMPROVEMENT OF LARGE SIGNAL INTERACTION MODEL FOR TWT

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[Article by Song Wenmiao [1345 2429 8693], Liu Yongquan [0491 3279 6898], and Wu Jingxian [0702 7234 6343], all of Institute of Electronics, Chinese Academy of Sciences*]

[Text] Abstract: Because of the nonconservation of energy in Rowe's model for large signal interaction in TWT, Towe's model produces considerable error in TWT design, especially for a velocity-tapered one. A modified model which is based on energy conservation is suggested to improve the accuracy of the design of TWT. By the new model, when the loss and space charge in TWT are neglected, the energy received by the circuit is exactly equal to that given by the electron beam. All the results obtained with the new model are in better agreement with the actual cases than those obtained with Rowe's model.

I. Introduction

Rowe's[1] theoretical model of helical TWT large signal interaction is still the most commonly used one in helical TWT design. As is pointed out in referenced [2-4], in Rowe's model there is the problem of non-conservation of energy, i.e., under ordinary circumstances, the energy received by the circuit is greater than the energy consumed by electron injection. References [4] discusses in particular detail the factors in non-conservation of energy and its relationship to some other factors. Analysis demonstrates that this energy difference is proportional to the gain parameter c and the idle component of the electron injection current's fundamental wave element. Therefore, as the electron injection's fundamental wave current increases, the energy difference also increases, that is, when the TWT work is near the asynchronous parameter b = 0, the influence of this energy non-conservation reaches its greatest point. And this state is the working state desired in phase velocity resynchronous technology.[5,6] Thus, to reflect more accurately the working state of a helical TWT under phase velocity tapering, it is necessary to improve Rowe's interaction model so that it can satisfy the universal laws of energy conservation.

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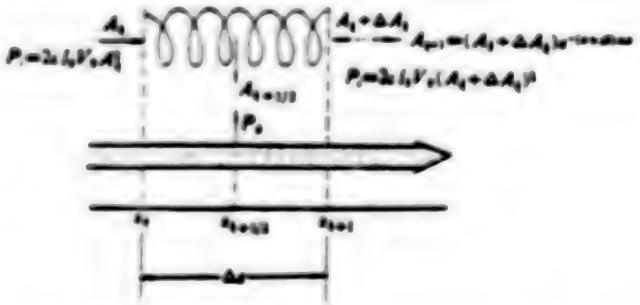
According to the analysis of reference [4], the basic reason that non-conservation of energy is produced is Rowe's equivalent lumped circuit and induced current mode. Thus we did not adopt the LC equivalent circuit model and voltage wave form, but made the field a variable directly. Nor did we adopt the induced current form for energy exchange, but made conservation of energy directly the basis for interaction between the field and electron injection. To make comparison easier, the new model still uses the normalization model and variable form used by Rowe, but similar variables here have a completely different significance. Comparing the computational results of the new model and Rowe's model one can see that (1) in the new model, energy is completely conserved, thus generally speaking, its efficiency is lower than Rowe's model, especially when b = 0, the difference is especially great. (2) In the new model, with similar input, the length of the action area required to reach saturation is slightly longer than in Rowe's model. (3) In the new model, the relationship of efficiency and asynchronous parameter is more acute than in Rowe's model, i.e., in the new model, as b changes, the change in efficiency is greater, especially when b approaches zero, efficiency drops faster than in Rowe's model. These points demonstrate that the new model conforms more closely to the actual situation than does Rowe's model.

II. Brief Account of the Physical Model

The physical model of interaction is illustrated in Figure 1. The figure presents the interaction situation within the area from z_k to z_{k+1}. Here $\hat{A}$ no

Figure 1. TWT Interaction Model (all A_k in the figure are $\hat{A}_k$)



longer represents voltage but directly represents the direct ratio to the "wave variable" of the electrical field. Because the backward wave is generally overlooked in the helical TWT, $\hat{A}$ is the direct wave. Here $\hat{A}$ is a complex number representing the amplitude and phase of the included wave. As a discretized method, we assume that the field between z_k and z_{k+1} is a constant, that is, there are no changes in amplitude and phase. After going through this area, a change occurs in the field, and this change comes about through superposition of two parts: (1) In this area electron injection excites the field, that is, as illustrated in Figure 1, the wave variable $\hat{A}_k$ changes into $\hat{A}_k + \Delta\hat{A}_k$. This excitation $\Delta\hat{A}_k$ can be found from the conservation of energy relationship, i.e., through computation letting $P_o = P_i + P_b$. (Here, P_o is the outlet power, P_i is the inlet power, P_b is the electron injection power.) (2) The attenuation and phase shift of the helix, i.e.,

$$\hat{A}_{k+1} = (\hat{A}_k + \Delta\hat{A}_k)e^{-(\alpha\Delta z + j\beta\Delta z)}.$$

Here, Δz is the distance between z_k and z_{k+1}, that is, the step size obtained from computation. From this assumption we can know that the external force exerted by the electrons in this area does not change. Therefore it should be uniformly accelerated motion.

The overall computation steps are roughly as follows: first we compute the electron motion in the given field; from electron motion, through the conservation relationship of electron injection power P_b, inlet power P_i, and exit power P_o we compute $\Delta\hat{A}_k$; $\hat{A}_k$ is added to the original $\hat{A}_k$, and the electron motion is computed again; this is repeated until convergence. However, the results of actual computations demonstrate that for precision to one one-thousandth generally convergence can be achieved in two iterations. Furthermore, in the iteration process, the space charge force does not change; this is because it is determined by the distribution of the inlet's space charge plate, and since it is not necessary to recompute the space charge force, the time required for computation is not long. After computing $\Delta\hat{A}_i$, Eq. (1) is used to find the wave variable of the next point and so on step by step until the entire path is computed.

III. Electron Field Expression

In analysis of helical circuits, it is actually only the relationship between the field and the power flow that is analyzed, and the impedance of the helix is computed from this[7,8]. In large signal analysis we also directly apply the results of references [7 and 8]. From this it can be seen that directly making the field a variable to establish the relational expression of power flow, impedance, and the electrical field is much more rational than through voltage. Thus we adopted:

$$P = \frac{|\hat{E}|^2}{2\beta^2 Z_0},$$

Here, in line with commonly used symbols, P is the power flow, $\hat{E}$ is the electrical field, β is the phase constant, and Z_0 is the coupled impedance.

To facilitate a comparison with Rowe's model, we also used Rowe's normalized variables. The variables used in the paper and whenever the definitions of the variables used by Rowe are the same, we will not add any explanation. The two normalized independent variables are the normalized distance y and time φ_0:

$$y = \frac{c\omega}{u_0} z,$$

and

$$\varphi_0 = \omega t_0.$$

The definition of velocity is:

$$\frac{dz}{dt} = u_0[1 + 2cu(y, \varphi_0)].$$

When the wave variable $\hat{A}$ is defined, we maintain the efficiency expression:

$$\eta = 2c|\hat{A}|^2.$$

Thus, the normalized wave variable $\hat{A}$ can be defined:

$$\hat{A} = \frac{c}{Z_0 I \beta}\hat{E},$$

Here, β is the phase constant of the cold circuit wave and not the phase constant of the hot wave in Rowe's model.

$$\beta = \frac{\omega}{u_0}(1 + bc).$$

IV. Electron Field Equations

Since we used the same normalized system, we adopted wholesale the expression of the space charge field from Rowe's book and changed only the expression of the high frequency field:

$$E_{sf} = \mathrm{Re}\left[\frac{Z_0 I \beta}{c}\hat{A}e^{j\theta}\right] = 2c^2\omega u_0(1 + bc)\mathrm{Re}(\hat{A}e^{j\theta}).$$

Thus we can obtain a motion equation similar to the one in Rowe's book:

$$[1 + 2cu(y, \varphi_0)]\frac{\partial u(y, \varphi_0)}{\partial y} = -(1 + bc)\mathrm{Re}[\hat{A} \cdot e^{j(\varphi(y,\varphi_0)+\varphi_0)}]$$
$$+ \frac{1}{4}\left(\frac{\omega_p}{\omega c}\right)^2 \cdot \int_{-\infty}^{\infty} \exp\left\{-\frac{1.25}{\beta_e b'}|\varphi(y,\varphi_0') - \varphi(y,\varphi_0)|\right.$$
$$\left.\cdot [1 + 2cu(y, \varphi_0')]\right\} d\varphi_0' \mathrm{sgn}[\varphi(y, \varphi_0') - \varphi(y, \varphi_0)].$$

Here b' is the electron injection radius, $\beta_e = \omega/u_0$. In general large signal computations we let

$$u_c(y, \varphi_0) = 1 + 2cu(y, \varphi_0).$$

therefore, Eq. (10) can be rewritten as:

$$\frac{\partial u_c(y, \varphi_0)}{\partial y} = [-(1 + bc)\mathrm{Re}(\hat{A}e^{j\theta}) + F_{sc}]2c/u_c(y, \varphi_0),$$

In which, F_{sc} is the second term on the right hand side of Eq. (10), and is the space charge force term. Regarding u_c on the right hand side of Eq. (12) as a known number, after discretization, we obtain

$$u_{i,k+1} = u_{i,k} - [(1 + bc)\mathrm{Re}(\hat{A}_{k+\frac{1}{2}}e^{j(\varphi_{k+\frac{1}{2}})}) - F_{sc}]\Delta y 2c/u_{i,k}.$$

In order to be more precise, we adopted

$$u^2_{i_{k+1}} = \{u^2_{i_k} - [(1 + bc)\,\mathrm{Re}(\hat{A}_{k+\frac{1}{2}} e^{j\varphi_{k+\frac{1}{2}}}) - F_{sc}]\Delta y 4c\}^{1/2}.$$

Here, $\hat{A}_{k+\frac{1}{2}}$ represents the field of the midpoint between z_k to z_{k+1}.

The results of computation demonstrate: For the situation $F_{sc} = 0$, Eq. (13) is adopted and the relative error of circuit power and electron injection power is about 2 percent at the time of saturation; and after adopting Eq. (13), the relative error of power was reduced to less than one thousandth which may be accepted as entirely computational error.

Since our velocity reference system was different from Rowe's, we used a natural system, therefore the phase equation changes to:

$$\frac{d\varphi(y, \varphi_0)}{dy} = \frac{1}{c} \cdot \frac{1}{[1 + 2cu(y, \varphi_0)]}.$$

V. Electron Injection Excitation of the Field

Electron injection excitation of the field is primarily computed through the energy conservation relationship. First of all, we found the power which a single charge plate exerted on the field through the region z_k to z_{k+1}. The power exerted by the ith charge plate on the kth step may be expressed:

$$\Delta U_{ik} = Q_D E_{rf_{ik}} \cdot \Delta z,$$

in which Q_D is the charge of the charge plate,

$$Q_D = \frac{I_0}{F N_d}$$

Here, N_d is the number of charge plates in each cycle and F is the frequency. Substituting Q_D and E_{rf} in Eq. (16) we get:

$$\frac{\Delta U_{ik}}{\Delta z} = \frac{I_0}{F N_d} \mathrm{Re}\left[\frac{Z_0 I_{ik}\beta}{c} \hat{A}_{k+\frac{1}{2}} e^{j(\varphi_{i_{k+\frac{1}{2}}} + \varphi_0)}\right].$$

Integrating all the charge plates in a cycle and dividing it by the cycle we obtain the excitation power which the electron injection gives to z_k to z_{k+1}:

$$\frac{\Delta P_{ik}}{\Delta z} = \frac{I_0}{2\pi}\int_0^{2\pi} \frac{Z_0 I_{ik}\beta}{c} \mathrm{Re}\,[\hat{A}_{k+\frac{1}{2}} e^{j(\varphi_{i_{k+\frac{1}{2}}} + \varphi_0)}]\, d\varphi_0.$$

Converting it to normalized coordinate y, we get:

$$\frac{\Delta P_{ik}}{\Delta y} = 4c I_0 V_0 \frac{1 + bc}{2\pi}\int_0^{2\pi} \mathrm{Re}[\hat{A}_{k+\frac{1}{2}} e^{j(\varphi_{i_{k+\frac{1}{2}}} + \varphi_0)}]\, d\varphi_0.$$

Here, it should be noted in particular that the electron field used was the electron field of the midpoint from z_k to z_{k+1}, this and the motion equation used are completely uniform.

The power obtained by the circuit in the z_k and z_{k+1} area is:

$$\Delta P_k = I_0 V_0 \Delta\eta = 2cI_0V_0[(\hat{A}_k + \Delta\hat{A}_k)^2 - |\hat{A}_k|^2]$$
$$= 4cI_0V_0\mathrm{Re}\left[\left(\hat{A}_k + \frac{\Delta\hat{A}_k}{2}\right)^* \cdot \hat{A}_k\right]$$

Here, * represents the complex conjugate. Let $\Delta P_k = \Delta P_{bk}$, and assume action in the field $\hat{A}_{k+\frac{1}{2}}$ on electron injection is the average of the inlet and outlet fields, i.e., let

$$\hat{A}_{k+\frac{1}{2}} = \left(\hat{A}_k + \frac{\Delta\hat{A}_k}{2}\right)$$

and

$$\varphi_{k+\frac{1}{2}} = \frac{1}{2}(\varphi_{k+1} + \varphi_k).$$

then we get the equation of the excitation field:

$$\Delta\hat{A}_k = \frac{1+bc}{2\pi}\int_0^{2\pi} e^{-j\varphi_{k+\frac{1}{2}}} d\varphi_0\,\Delta y.$$

under normalized conditions, Eq. (1) changes to:

$$\hat{A}_{k+1} = (\hat{A}_k + \Delta\hat{A}_k)e^{-j\left(\frac{1+bc}{c}\right)\Delta y - [illegible]}.$$

Eqs. (14), (15), (22), (23), (24), and (25) form a complete working equation group. Since these six equations are very simple algebraic equations, they are very easy to solve, and the solutions are very stable. No particular explanation is required for computation of these equations. Here we will only explain simply the next process in the overall solution: under known initial conditions, first from solving the electron motion equations from Eqs. (14) and (15) we find the normalized velocity u_{ck+1} and phase φ_{k+1} (for the first iteration, let $\Delta\hat{A}_k^{(1)}=0$ and $\varphi_{k+\frac{1}{2}}^{(1)}=\varphi_k$). Then from Eq. (24) find $\Delta\hat{A}_k^{(2)}$, and then use Eqs. (22) and (23) to find a new $\hat{A}_{k+\frac{1}{2}}$ and $\varphi_{k+\frac{1}{2}}$. Then carry out a new iteration, i.e., once again solve the electron motion equation from Eqs. (14) and (15), and compute a new $\Delta A_k^{(3)}$. This is repeated until $|\Delta A_k^{(n+1)} - \Delta A_k^{(n)}| < \varepsilon$, ε is the given error. Since under ordinary conditions $\Delta\hat{A}_k$ is much smaller than A_k, the speed of convergence of this iteration is very fast.

For computation of the space charge field, inlet charge plate distribution is used, but not the charge plate distribution at $z_{k+\frac{1}{2}}$. The computation of the space charge field is unrelated to number of iterations, the iterations only change the high frequency field. This saves a great deal of time, but at the same time can introduce some error. In addition, the suppositions of Eq. (22)

can also introduce error. All these errors not only are related to step length but also are related to degree of excitation, and the stronger the excitation, the greater the error. To reduce these errors, we adopted a method to change the step length.[2] The stronger electron injection bunching, the smaller the step length, generally until saturation is at $\Delta y < 0.02$. With such a small step length, the error introduced by these factors is not very large.

VI. Computation Results

A program using the new model computations has already been set up. Figure 2 gives the changes in power along the axial distance at different cs and bs when $Q_c = 0$ and $d = 0$, and at the same time gives the results using Rowe's model for comparison. The solid line in the illustration is the result using the new model. Since here we did not take into account loss and space charge force, the power flow and the power flow of electron injection loss in the circuit computed using the new model are almost completely equal. As for Rowe's model, between the two there is a certain difference. The dotted line represents the circuit efficiency, N_c:

$$\eta_c = 2c|A|^2;$$

and the broken line represents the efficiency obtained from electron injection power consumption,

$$\eta_b = \frac{1}{N_A}\sum_{i=1}^{N_A}[1-(1+2cx_i)^2].$$

For the new model, the difference of N_c and N_b in all computation results is smaller than 0.01 percent, therefore only a curved line could be drawn in the illustrations. For Rowe's model, under all conditions, N_c was always greater than N_b. The results of the new model are also smaller than the N_b of Rowe's model. These are all equal to the anticipated results. These three efficiency differences increase as c increases; and increase as b diminishes. Figure 2(a) and Figure 2(b) are the results when $b = 1$ under different cs, their efficiency difference is small, but Figure 2(c) and Figure 2(d) are the results when $b = 0$, and the corresponding efficiency differences are much greater. Table 1 gives the computational results under saturation to compare more clearly the efficiency errors of the different models under different synchronous conditions. Here, using Rowe's model,

$$\eta_{c,R} = 2cA^2\frac{[1-cd\theta/dy]}{(1+bc)}.$$

If δ_n, is used to represent the relative error of the two efficiencies themselves when Rowe's model is used, then

$$\delta\eta_1 = \frac{\eta_{c,R}-\eta_{b,R}}{\eta_{b,R}};$$

if δ_{n2} is used to represent the relative error between circuit efficiencies under the two models, then

$$\delta\eta_2 = \frac{\eta_{c,R}-\eta_c}{\eta_c}.$$

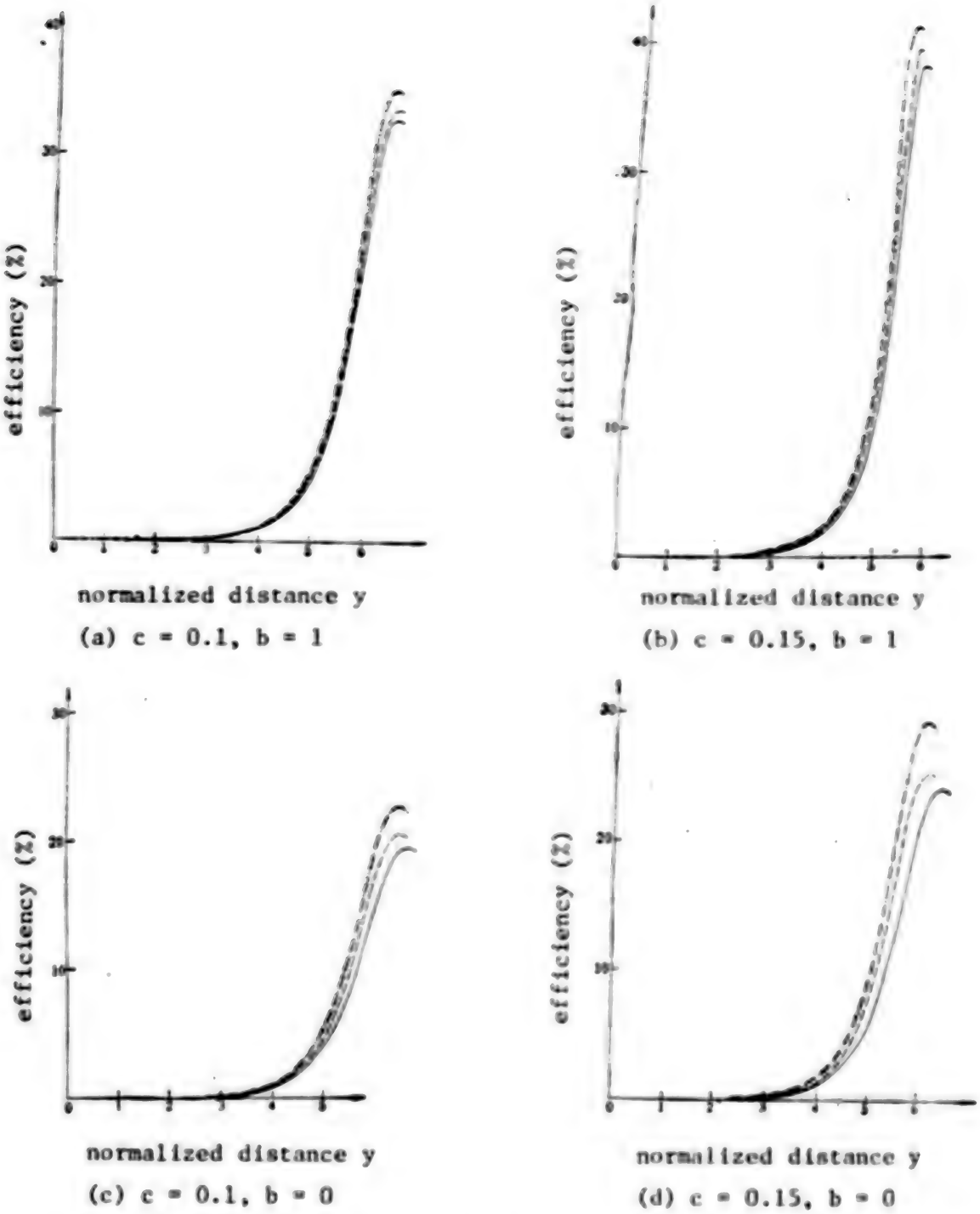


Figure 2. Relationship of efficiency and normalized distance in two models (Q_c = 0, d = 0)

-·- circuit efficiency of Rowe's model
--- electron injection efficiency of Rowe's model
——— efficiency with new model (both efficiencies are equal)

Table 1. Efficiencies and Errors of the Two Models

Efficiencies and errors	$c = 0.1$				$c = 0.15$			
	$b = 1$		$b = 0$		$b = 1$		$b = 0$	
	Rowe's model	New model	Rowe's model	New model	Rowe's model	New model	Rowe's model	New model
η_n	36.34	32.75	23.90	19.44	41.20	38.10	32.59	24.30
η_R	33.49	32.75	20.29	19.44	39.30	38.10	25.52	24.30
$\delta\eta_1$	8.51		17.79		4.83		27.70	
$\delta\eta_2$	10.96		22.94		8.13		34.11	

Here, N_n is the efficiency when using the new model in this paper. In this case, the b = 1 group is the situation when close to optimum efficiency; and the b = 0 group represents the work situation when a harmonic current is made to be maximum. When b = 1, the relative difference between the two models is smaller, generally smaller than 10 percent; but for the b = 0 situation, the relative error under the two models is as great as 20 to 30 percent. This also means that ar 'mproved interactive model is even more necessary for variable speed computations.

The above computations were carried out under circumstances in which Q_c and d were equal to zero. This was to save computation time, but also it was because under such ideal conditions, it is most easy to check for problems of the interactive model itself. After taking into account the space charge force and loss, the situation also should be the same. In computation of variable speed, we considered all practical factors. Figure 3 is the computation results for variable intercept. The first segment parameters are: c - 0.078, b = 0, Q_c = 0.15, β_{eb}' = 0.51, d = 0.05, R = 0.51; parameters after intercept tapering are: c = 0.068, b = 5, Q_c = 0.25, β_{eb} = 1.0, d = 0.05, R = 0.59. These parameters were obtained from computation of the helical velocity and impedance of actual TWT. The solid line in Figure 3 represents the changes in efficiency with normalization distance, the dotted line represents the fundamental wave component of the current, and the broken line represents the phase difference between the injection current and the electron field. From Figure 3 it can be seen clearly the process of phase bunching and rebunching of electron injection produced by variable intercept. In the vicinity of the point of gradual change, the changes in the phase difference of the bunching center and the electron field is very fast, and after it reaches the saturation point it enters the area of acceleration, and at the same time, the fundamental wave element of the electron injection current drops sharply, i.e., the electron injection begins to debunch; and after adding variable intercept, the phase difference once again falls into the area of decreasing speed, and the injection's fundamental wave current also no longer decreases, and within one segment after that, it is maintained at a certain level.

Because Rowe's model is a second order partial differential equation, when computing the variable intercept, the influence of boundary conditions is very

great, and frequently instability can appear. The new model has overcome this shortcoming, and since the equation is a first order differential equation, boundary conditions are easily given, and under most circumstances, computation results are stable. Discussion of the computation, analysis, and design of variable speed problems and their comparison with the experimental results will not be carried out here due to limitations of space.

VII. Conclusion

The above computation results can show that the new model has many superiorities over Rowe's model. Primarily, it realized conservation of energy, and improved computation precision; when b = 0, the significance of this revision is even greater. Thus, in computation of variable intercept, the new model should have even greater superiority.

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EXPERIMENTAL EXPERT SYSTEM, 'BLOCK,' FOR USE IN CIRCUIT DESIGN

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7 No 2, Mar 85 pp 92-97

[Article by Fang Yongsui [2455 3057 4840] of the Institute of Electronics, Chinese Academy of Sciences; Lu Jiren [7120 0165 0086] of Nanjing Engineering College; Hu Zongxuan [5170 1350 3551] of Shandong University; and Wang Zhaoming [3769 0340 2494] of Chendu Institute of Telecommunications Engineering*]

[Text] Abstract: A practical expert system called "Block" is created for analog circuit design, the goal being to use this research to implement ways and means of high level circuit expert systems. "Block" system only requires the output and input signal demands of the given circuit to complete the block design of the circuit automatically and rapidly while these tasks ordinarily must be done by the circuit designer.

I. Expert Systems and Basic Concepts

The expert system is an important and useful aspect of artificial intelligence. In 1979, A. Simon[1] reported the use of the experimental expert system Bacon-3 in discovering physical laws. In recent years, in China and abroad on the basis of their own needs scholars in various fields have cooperated with computer specialists to explore and develop expert systems which have been used on a trial basis in medical diagnosis, geological exploration, and petroleum engineering. This paper reports the preliminary results of our research on an expert system for circuit design.

Existing computer aided circuit design (CAD) generally demands that the machine be allowed to know the topology and the nature of the elements in the circuit then the machine would adjust and improve the parameters of the elements until the demands were satisfied. That is, selection of the basic structure of the circuit (the topology and the nature of the elements) was carried out by the human brain and not by the machine. An expert system for circuit design should only require the output and input demands (and other additional demands) on the circuit, and on the basis of the specialized knowledge of circuits which the

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system has mastered, it automatically selects the circuit's topology and the nature of the elements and designs a circuit which will satisfy the demands. For this, the following two problems have to be resolved[2]:

(1) How to express knowledge of circuit design, such as circuit laws, the characteristics of active elements and inactive elements, integrated circuit parameters, and methods of synthesizing circuits into a form suitable for the computer to master and structure it into the necessary and complete system, i.e., the problem of creating a knowledge base.

(2) Developing a suitable heuristic procedure so that on the basis of the demands of the problem and the knowledge in the knowledge base the computer will find the answers.

Setting up an expert system which can resolve design questions for different types of complex circuits will be a topic which will take a great deal of work. To explore the ways and means, we first limit the problem to a smaller scope.

Here, the design of analog circuits is expressed as finding a system which can carry out the conversion of one group of input spectral lines into another group of output spectral lines i.e., it can be thought of as a problem of frequency domain so that the computer can process it, and this can be written.

$$[V_1(\omega),\ I_1(\omega)] \xrightarrow{C=?} [V_2(\omega),\ I_2(\omega)],$$

in which

$$V_1(\omega) = \int_{-\infty}^{\infty} v_1(t)e^{-j\omega t}\,dt, \qquad I_1(\omega) = \int_{-\infty}^{\infty} i_1(t)e^{-j\omega t}\,dt;$$

$$V_2(\omega) = \int_{-\infty}^{\infty} v_2(t)e^{-j\omega t}\,dt, \qquad I_2(\omega) = \int_{-\infty}^{\infty} i_2(t)e^{-j\omega t}\,dt;$$

$v_1(t)$ and $i_1(5)$ are the known signal voltage and signal current of the input terminal of the circuit to be found; $v_2(t)$ and $i_2(5)$ are the known signal voltage and signal current of the output terminal of the circuit to be found; C represents the conversion system needed, i.e., the circuit to be designed.

When $v_1(t)$, $v_2(t)$, $i_1(t)$, and $i_2(t)$ are the cycle functions of time, the corresponding $V_1(w)$, $V_2(w)$, $I_1(w)$, and $I_2(w)$ are discrete and can be expressed as

$$\text{voltage input} = [\omega_i^{iv} \mid \phi_i^{iv}] = \begin{bmatrix} \omega_0^{iv} & \phi_0^{iv} \\ \omega_1^{iv} & \phi_1^{iv} \\ \vdots & \vdots \\ \omega_m^{iv} & \phi_m^{iv} \end{bmatrix},$$

$$\text{voltage output} = [\omega_i^{ov} \mid \phi_i^{ov}] = \begin{bmatrix} \omega_0^{ov} & \phi_0^{ov} \\ \omega_1^{ov} & \phi_1^{ov} \\ \vdots & \vdots \\ \omega_m^{ov} & \phi_m^{ov} \end{bmatrix},$$

in which $\omega_i^{iv}(i=0,1,\cdots,n)$ is the spectral line of the frequency in the input voltage, $V_i^{iv}(i=0,1,\cdots,n)$ is the complex amplitude which the spectral line W_I^{IV} has; $\omega_j^{ov}(j=0,1,\cdots,m)$ is the spectral line of the frequency in the output voltage, V_j^{ov} is the complex amplitude of the spectral line W_j^{ov}.

$$\text{current input} = [\omega_i^{ic} \vdots I_i^{ic}] = \begin{bmatrix} \omega_0^{ic} & \vdots & I_0^{ic} \\ \omega_1^{ic} & \vdots & I_1^{ic} \\ \vdots & \vdots & \vdots \\ \omega_k^{ic} & \vdots & I_k^{ic} \end{bmatrix},$$

$$\text{current output} = [\omega_j^{oc} \vdots I_j^{oc}] = \begin{bmatrix} \omega_0^{oc} & \vdots & I_0^{oc} \\ \omega_1^{oc} & \vdots & I_1^{oc} \\ \vdots & \vdots & \vdots \\ \omega_p^{oc} & \vdots & I_p^{oc} \end{bmatrix},$$

in which $\omega_i^{ic}(i=0,1,\cdots,k)$ is the spectral line of the frequency in the input current, $I_i^{ic}(i=0,1,\cdots,k)$ is the complex amplitude which the spectral line W_L^{IC} has; $\omega_j^{oc}(j=0,1,\cdots,p)$ is the spectral line of the frequency in the output current, $I_j^{oc}(j=0,1,\cdots,p)$ is the complex amplitude which the spectral line W_g^{oc} has.

Below we introduce certain basic concepts and symbols to aid the discussion.

(1) Input, output and states

INP--a group expressing the completeness of a system terminal input signal, called input, for short, specific content is as illustrated in Eqs (2) and (4), it also can take other forms;

OUT--a group expressing the completeness of a system terminal input signal, called output, for short, specific content is as illustrated in Eqs (3) and (5), it also can take other form;

S_i--a group expressing the completeness of a signal at an intermediate location i in the system, called 'state' for short. S_1 = INP, is also called initial state.

S_f = OUT is end state.

(2) Differential functions

$D(S_i,S_j)$--used to express the difference of signal in states S_i and S_j i$_e$ of a group completeness;

D(INP,OUT)--used to express the difference of input and output of a group completeness; and

$D(INP,OUT)=D(S_1,S_f)$; $D(S_i,S_j)=0$ indicates that S_i and S_j are the same, i.e., there is no difference.

(3) Goals

The task that must be resolved to make part (one element is zero) or all of the differential function $D(S_i,S_j)$ is zero, is called the goal $G_{i,j}$.

(4) Operators

Operators are the specific techniques of realizing goals. In this paper, it represents a circuit block having a certain function. The operator $R_{i,j}$ makes the signal in state S_i change to state S_j through its conversion, written $S_i \xrightarrow{R_{i,j}} S_j$, the concatenation relationship in the operator is expressed as a multiplication sign, i.e., $R_{i,j} \cdot R_{j,k} = R_{i,k}$.

(5) Knowledge base

The information gathered is controlled by, computer programs, and is expressed by program decision rules or memory contents. According to this, the machine can find the corresponding operator depending on the goal.

Figures 1 and 2 give two possible forms of the circuit building expert system we are considering. When setting up the "Block" system, we adopted the form in Figure 1.

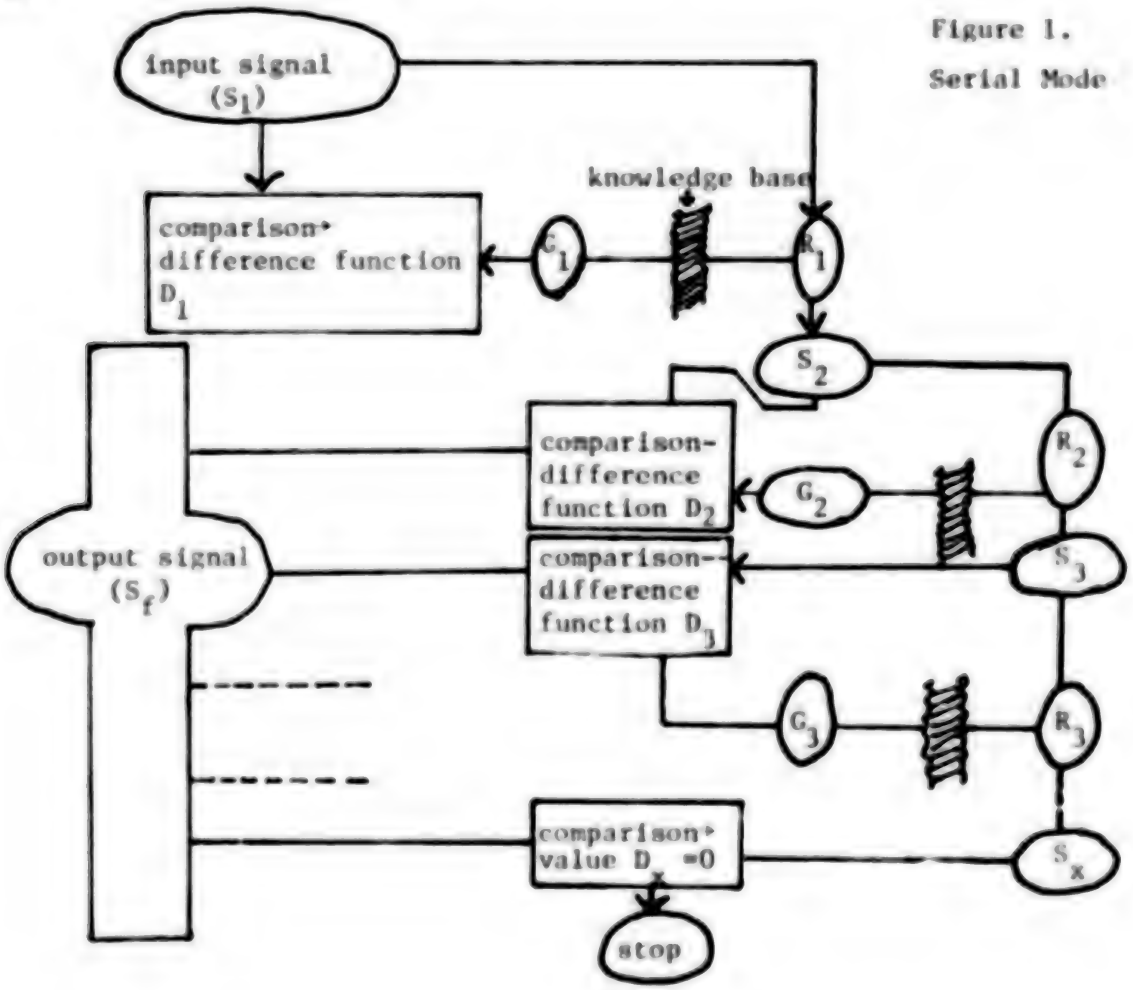


Figure 1.
Serial Mode

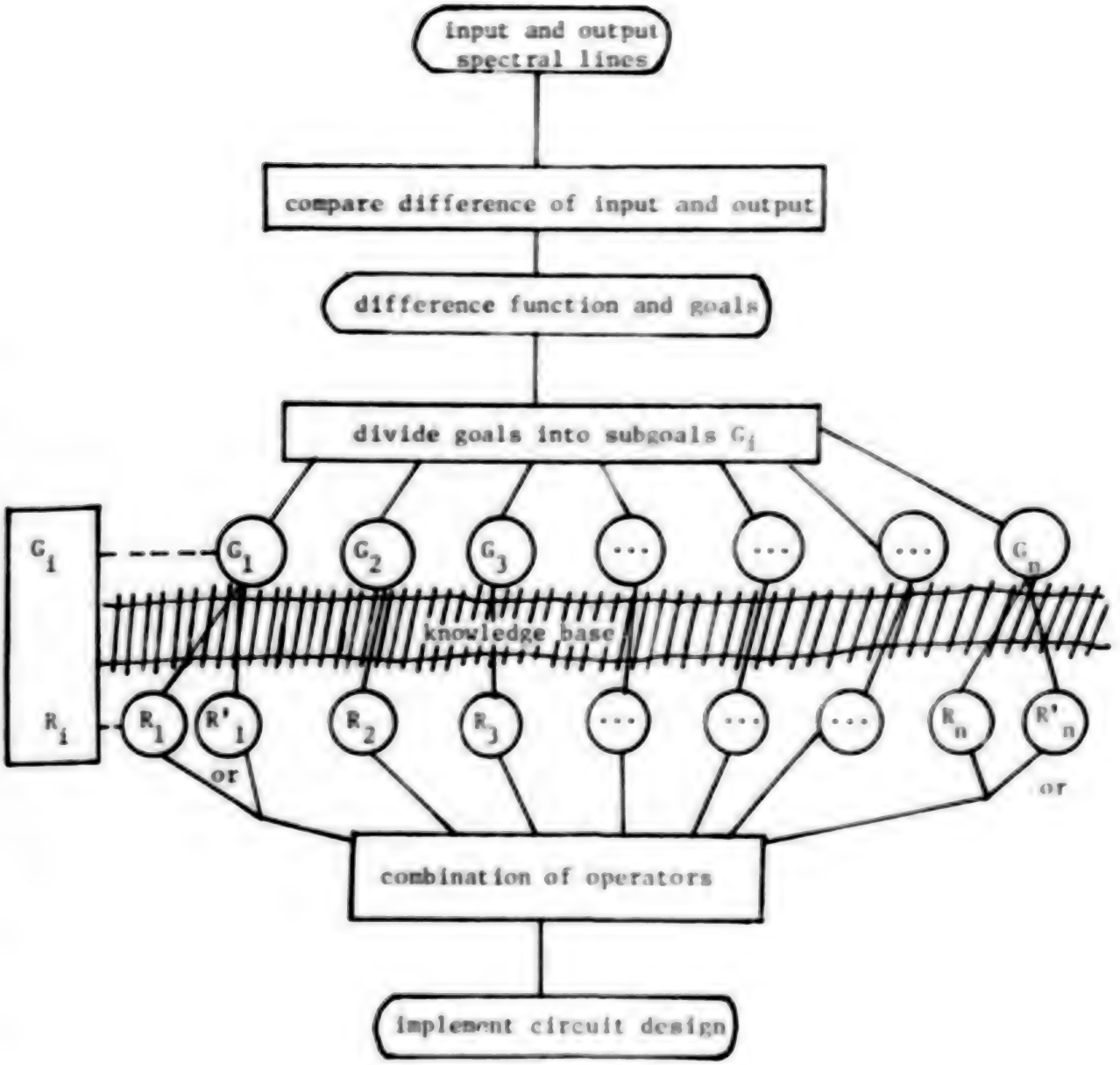


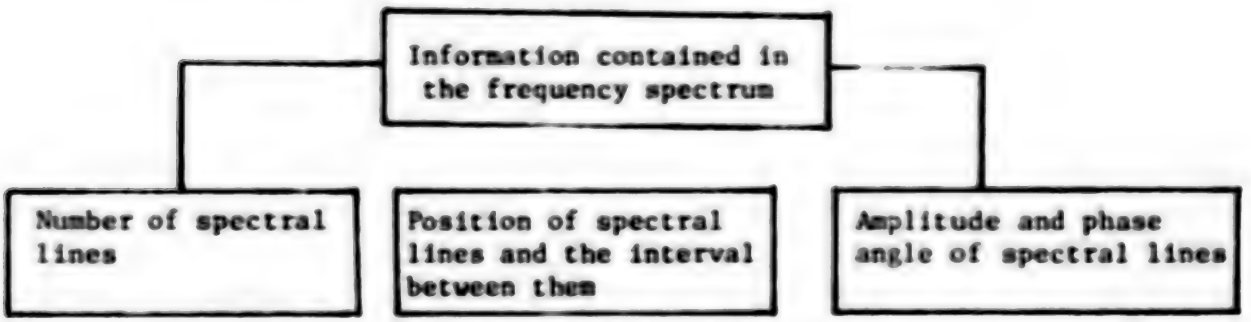
Figure 2. Parallel mode

II. Main Points of the "Block" System

After the "Block" system receives the input spectral group INP and the output spectral group OUT of the circuit to be designed, it carries out a series of comparison on them to find the difference function and determine the goal, and finds the operator to realize the goals through decision. The complete signal used for comparison and decision is the number of spectral lines, the position of spectral lines (i.e., the frequencies) and the intervals between them, and the amplitude and phase angle of each spectral line, as illustrated in Tables 1(a), (b), and (c).

Table 1

(a) Information contained in the frequency spectrum



(b) Information contained in a single spectral line

Position W_i	Amplitude A_i	Phase angle φ_i

(c) Information contained in spectral group

Position difference $W_{i+1}-W_i$	Amplitude difference $A_{i+1}-A_i$	Phase angle difference $\varphi_{i+1}-\varphi_i$
Relative position difference $\frac{W_{i+1}-W_i}{W_i}$	Relative amplitude difference $\frac{A_{i+1}-A_i}{A_i}$	Relative phase difference $\frac{\varphi_{i+1}-\varphi_i}{\varphi_i}$

Below are the important steps in comparison and decision:

(1) Compare the N_1 and N_o, the number of spectral lines contained in INP and OUT, if $N_1<N_o$, then invoke the non-linear portion operator ("oscillator" and "mixer") to wait for a command;

(2) Eliminate spectral lines of identical frequency contained in INP and OUT, and if some of the spectral lines in OUT are not eliminated, then invoke the non-linear operator, otherwise, invoke the linear operator ("filter," "amplifier," and "attenuator");

(3) Check to see if there are some spectral lines in INP which have not yet been eliminated, and if there are any, call the operator "filter" to wait for a command;

(4) Compute the amplitude ratio between the spectral lines of identical frequency contained in INP and OUT, and if the amplitude ratio is not a constant, then call the operator "filter" to wait for a command, otherwise compute gain A;

(5) If A>0, then call operator "amplifier" to wait for a command, if A<0, then call operator "attenuator" to wait for a command, otherwise call operator "short circuit line."

The comparison and decision carried out on the program flow branch will further analyze in detail the content of the operator waiting for a command to determine the specific type and the appropriate parameters. This is omitted here.

In the knowledge base there are also some standard operators, such as standard amplifier 1, standard amplifier 2,... etc. If they should be suited to the demands of the performance parameters required in a problem, then the machine will propose it. In order to simplify matters, the features of the operators have been idealized for the time being, for example, filters do not calculate loss, mixer efficiency is 1, etc.

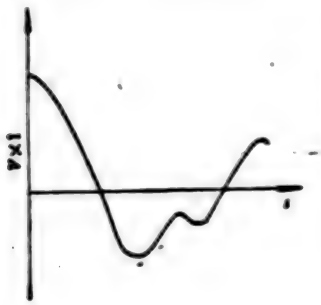
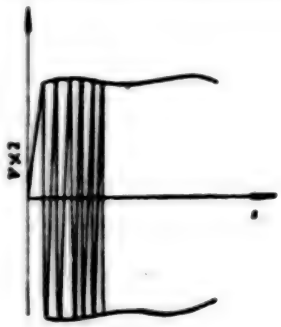
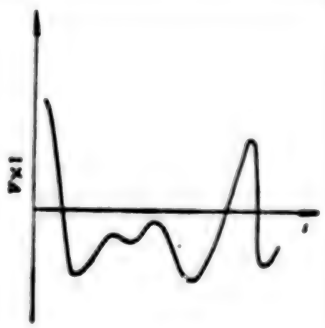
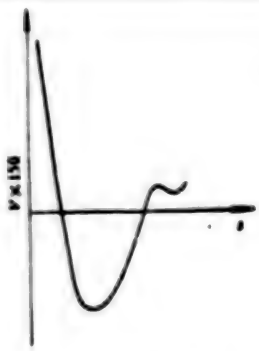
III. Checking Examples and Brief Conclusion

We used a program of about 700 statements in FORTRAN-IV for the above described "Block" system. The system's capabilities are as illustrated in the two conventional assessments in Table 2.

Since the specialized knowledge which can be given to a machine is still very limited, "Block" is only an experimental system, whose primary aim is to clarify some of the problems encountered in constructing an expert system and how to resolve them, and to provide a basic model for further work.

Owing to large-scale application of integrated circuits at present, circuits are becoming more and more modularized. The work of circuit designers need not be meticulous about deciding on single basic components (transistors, resistors, capacitors, and inductors), but to a large degree need only decide on the block diagram and modules of the circuit, especially for digital cir-

Table 2 Assessment Examples

Input circuit designed INP	Output circuit designed OUT	Computer responses to problems
 kHz $[\omega_i \mid V_i] = \begin{bmatrix} 50 & 5.0 \\ 60 & 6.0 \\ 80 & 7.0 \\ 100 & 6.0 \\ 110 & 5.0 \end{bmatrix}$	 kHz $[\omega_i \mid V_i] = \begin{bmatrix} 1130 & 10.0 \\ 1140 & 12.0 \\ 1160 & 14.0 \\ 1180 & 12.0 \\ 1190 & 10.0 \end{bmatrix}$	(1) First cut in a mixer, frequency f_C=1080kHz, then connect a filter as described in (2); (2) one bandpass filter, with these characteristics: central frequency f_0 1159kHz bandwidth Δf=86kHz series N=7 (Butterworth model) (3) one amplifier, characteristics: central frequency f_0'= 1160kHz bandwidth $\Delta f_0'$=60kHz gain G=6.02dB This proposal used No. 2 standard amplifier.
 kHz $[\omega_i \mid V_i] = \begin{bmatrix} 2005 & 0.1 \\ 3400 & 0.1 \\ 5000 & 0.1 \\ 5100 & 0.1 \\ 5300 & 0.1 \\ 7600 & 0.1 \\ 7800 & 0.1 \end{bmatrix}$	 kHz $[\omega_i \mid V_i] = \begin{bmatrix} 5000 & 15.0 \\ 5100 & 15.0 \\ 5300 & 15.0 \\ 7600 & 15.0 \\ 7800 & 15.0 \end{bmatrix}$	(1) requires only a linear module (2) first cut in high pass filter with the following characteristics: central frequency f_0=6400kHz bandwidth Δf=3000kHz series N=24 (Butterworth model) then connect an amplifier as described in (3) (3) one amplifier with the following characteristics: central frequency F_0'=6400kHz bandwidth $\Delta f'$=2800kHz gain G=43.52dB no standard amplifier can be found.

cuits. On the other hand, the types of integrated blocks is legion, and searching handbooks and data is very time consuming, thus setting up an expert system with a knowledge base of relevant knowledge and data so that the machine will be able to replace man in carrying out some design appears to be very essential. The work of this article shows that it is also completely possible.

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APPLIED SCIENCES

VERTICAL POLARIZED ANTENNA FOR SYNTHETIC APERTURE RADAR

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[Article by Wang Ruxian [3769 3067 6343] and Shen Guanhong [3088 6306 5725], Institute of Electronics, Chinese Academy of Sciences*]

[Text] Abstract: This paper describes a simple design method of a vertical polarized antenna operated in the X-Band. This antenna consists of longitudinal shunt slotted array at the broad side of rectangular waveguide and metallic horned plates. A full size model was fabricated. The computed results are in agreement with measured ones approximately. Although this method is preliminary, it has practical value in antenna design.

I. Introduction

Synthetic aperture radar is imaging radar. It carries out imaging of the plotting region's ground targets. Usually, the radar antenna only radiates horizontal polarized electromagnetic waves, but because of the variety and complexity of the ground target, frequently there is a conversion effect of the polarization of the electromagnetic waves. So that the radar can collect more remote sensing information of ground targets, it is clearly not enough just to make polarized emission and reception. Thus, on the basis of an antenna which radiates horizontal polarized waves, we have developed an antenna which radiates vertical polarized waves and provided a radar prototype for flight test imaging and image comparison.

In designing the vertical polarized antenna we used a waveguide slotted array and a horned structure. Its external shape, dimensions and main electrical performance is basically the same as antennas which radiate horizontal polarized waves. However, the slotted waveguide used by the vertical polarized antenna: it opens a series of longitudinal off-axis shift slots on the broad side of a rectangular waveguide to radiate vertical polarized electromagnetic waves.

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II. Vertical Polarized Waveguide Slotted Array

The conductance of the harmonic slots can be computed using the formula[1]

$$G = G_0 \sin^2\left(\frac{\pi x}{a}\right).$$

In the Eq.: $G_0 = 2.09 \frac{\lambda_g}{\lambda}\left(\frac{a}{b}\right)\cos^2\left(\frac{\pi\lambda}{2\lambda_g}\right)$, λ is the free space wave length, λ_g is the waveguide wave length, a is the waveguide wide side dimensions, b is the waveguide narrow side dimensions; x is the distance between the slotted center line and the waveguide axis line.

For a traveling wave type array, the reflection coefficient ρ of the input can be computed using the formula[2]

$$\rho = \frac{-\sum_{n=1}^{N} \frac{1}{2} G_n e^{-j n \beta_g d}}{1 + \sum_{n=1}^{N} \frac{1}{2} G_n}$$

In the Eq. $\alpha_g = 2\pi/\lambda_g$, N is the number of slots, d is the spacing of adjacent slots, G_n is the conductance of the nth slot in the array.

When frequency changes are not great, one can tell that ρ is only related to $2\alpha_g nd$. When $d = n_g/2$, ρ is at its greatest, it is necessary to avoid making d equal to $n_g/2$. We took $d = 0.53n_g$. Changing the direction of adjacent slot spacing wave guide axial lines one can obtain a 180° phase difference.

The efficiency of the traveling wave array has the following relationship with the normalized conductance[3]:

$$\frac{G_i}{Y_0} = \frac{P_{ri}}{\frac{1}{\eta}\sum_{i=1}^{N} P_{ri} - \sum_{i=1}^{i} P_{ri}}.$$

in which, G_i/Y_0 is the normalized conductance of the ith slot. η is the radiation efficiency of the slotted array, P_{ri} is the normalized radiation power of the ith slot.

The maximum normalized conductance that we actually selected was $G/Y_0 = 0.1$, the slotted array opening face was designed for equal magnitude distribution, the following equation can be used to compute its H-plane directional map[2]:

$$E(\theta) = \frac{\sin\left[\frac{N}{2}\left(\frac{2\pi}{\lambda} d \sin\theta - \frac{2\pi}{\lambda_g} d + \pi\right)\right]}{\sin\left[\frac{1}{2}\left(\frac{2\pi}{\lambda} d \sin\theta - \frac{2\pi}{\lambda_g} d + \pi\right)\right]}.$$

III. E-plane Directional Map

The field distribution on the E-plane of the vertical polarized antenna can be seen to be similar to the electrical field distribution on the E-plane's fan-shaped horned aperture face. Thus, the computational formula for the E face fan-shaped horned E-plane directional map can be used to compute approximately the E-plane directional map of the vertical polarized waveguide slotted array horned antenna.

The equation for the E-plane directional map of a known E-face fan-shaped horn is[2]:

$$E(\theta) = -j\frac{E_0 b'' a''}{4\sqrt{2n_1}\lambda R}\left(\cos\theta + \frac{W}{W_0}\right)e^{-j(\varphi_z - \frac{u^2}{4n_1})} \cdot \left\{\left[C\left(\sqrt{2n_1} - \frac{u}{\pi\sqrt{2n_1}}\right) + C\left(\sqrt{2n_1} + \frac{u}{\pi\sqrt{2n_1}}\right)\right] + j\left[S\left(\sqrt{2n_1} - \frac{u}{\pi\sqrt{2n_1}}\right) + S\left(\sqrt{2n_1} + \frac{u}{\pi\sqrt{2n_1}}\right)\right]\right\}.$$

in which θ is the angle of direction; a" is the dimension on the horn aperture face parallel to the direction of the magnetic field; b" is the dimension on the horn aperture face parallel to the direction of the electrical field; E_0 is the electrical field strength in the center of the aperture face; R is the distance of the antenna phase center to the observation point; W_0 is the free space wave impedance; W is the wave impedance in the dielectric; C(Z) and S(Z) are Fresnel's integrals,

$$C(Z) = \int_0^Z \cos\left(\frac{\pi x^2}{2}\right)dx, \quad S(Z) = \int_0^Z \sin\left(\frac{\pi x^2}{2}\right)dx;$$

R' is the horn length; $n_1 = b''^2/4\lambda_g R'$; $u = (\pi/\lambda)b'' \sin\theta$; $\varphi_z = \pi b''^2/4\lambda_g R'$.

The antenna gain g can be approximated using the formula

$$g = \frac{41000}{\theta_E \theta_H}\eta_g\eta_{Eh}$$

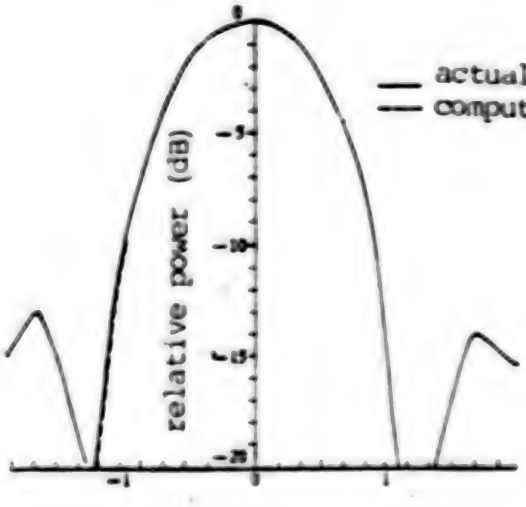
In the formula θ_E and θ_H are the 3dB beam width (°) of the E-plane and H-plane directional maps respectively, η_g is the slot waveguide array's radiation efficiency (%), η_{Eh} is the E-face fan-shaped horn's aperture face utilization coefficient (%).

IV. Comparison of Computed and Measured Results

1. Computed results: The results of the design computations using the above described method are: we used a rectangular brass waveguide, walls of 1mm thickness, cross section area of 23 x 10mm^2; 62 longitudinal slots 16mm long and 1.59mm wide were cut in the wide side of the waveguide, distance between adjacent slots was 23.67mm, the maximum distance of the slot offset from the waveguide axis was 2.11mm; the E-plane aperture opening angle was 34°, the

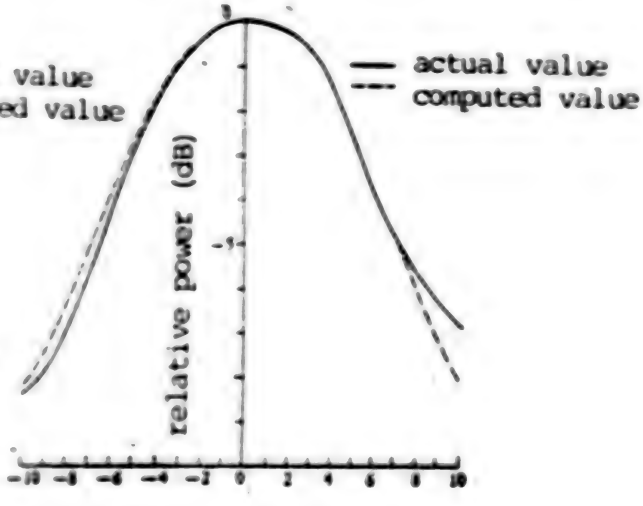
aperture face width was 155mm, aperture face length was 1500mm, E-plane 3dB beam width was 11.2°, H-plane 3dB beam width was 1.1°. If the aperture face utilization coefficient of the waveguide slotted array horn is taken as 0.66, then the gain is estimated at 32dB, computed value of the center frequency's voltage drive wave ratio is 1.18, the efficiency of the waveguide slotted array is 86 percent.

2. Measured Results: The voltage drive wave ratio of the waveguide slotted array in the usage frequency band is less than 1.15, efficiency is 85 percent, the gain is 31.5dB, the beam directional load deflection angle is 2.4; H-plane 3dB beam width is 1.2°, its directional map is illustrated in Figure 1. The E-plane 3dB beam width is 10.8°, its directional map is illustrated in Figure 2.



directional angle (θ°)

Figure 1. H-plane directional map



directional angle (θ°)

Figure 2. E-plane directional map

V. Conclusion

A narrow face waveguide inclined slotted array horned antenna has already been applied widely, but a horned antenna array which radiates vertical polarized waves is still little used. We developed an experimental antenna according to the method described in this paper. Its conductance distribution was designed according to the measured conductance curve. Radar flight tests demonstrate that this antenna basically satisfies use demands. From this it can be seen that although the design method described in this paper is simple and crude, it has definite practical value.

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APPLIED SCIENCES

CY SERIES INTEGRATED PRESSURE TRANSDUCER

Beijing DIANZI KEXUE JISHU [ELECTRONIC SCIENCE AND TECHNOLOGY] in Chinese
No 12, 10 Dec 84 pp 25-26, 28

[Article by Bao Minhang [7637 2404 2635] and Jiang Jishen [5592 4949 3947]]

[Text] The CY series integrated pressure transducer is a brand-new third generation semiconductor pressure-sensing element whose primary performance indicators have reached or surpassed the advanced levels for similar products abroad.

In order to make the transducer have ideal performance parameters, the CY series pressure transducer integrates on one chip a pressure sensitive bridge, signal amplification circuit, and temperature compensation circuit.

Since silicon material <100> crystal orientation has a mature etching process and at the same time is more ideal for integrated circuit process, therefore P-type <100> crystal orientation silicon chips were chosen for the CY_series products, and pressure-sensitive resistance lines follow <011> and <011> crystal orientation.

A typical circuit of a CY series integrated pressure transducer is illustrated in Figure 1.

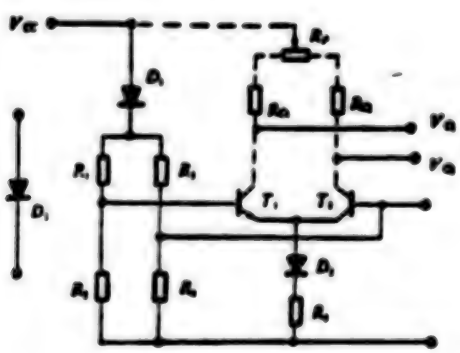

Figure 1. Typical circuitry of integrated pressure transducer

R_1-R_4 is the pressure sensitive resistance bridge, connected as a Wheatstone bridge. The circuitry of this method of connection is simple and has a high degree of precision and sensitivity. When the externally applied pressure is zero, $R_1 = R_2 = R_3 = R_4 = R$, and the bridge output $V_0 = 0$. When the externally applied pressure is P, $\Delta R_1 = \Delta R_4 = -\Delta R_2 = -\Delta R_3 = \Delta R$, and at this time the bridge output

$$V_o = KP(V_{cc} - V_{be}) \qquad (1)$$

in which K is a constant, P is the externally applied pressure, V_{be} is the forward voltage drop of diode D_1.

The amplification part uses a differential amplification circuit. The signal is input from the bases of two differential transistors T_1 and T_2, and the output is the difference in voltage of the collectors of the two transistors.

The voltage of the entire circuit's output signal is

$$V_{out} = (V_{cc} - V_{be})(V_{cc} - 5V_{be})KP \cdot \frac{q}{K_0 T} \cdot \frac{R_c}{4R_0} \qquad (2)$$

The pressure response curve drawn according to formula (2) is illustrated in Figure 2.

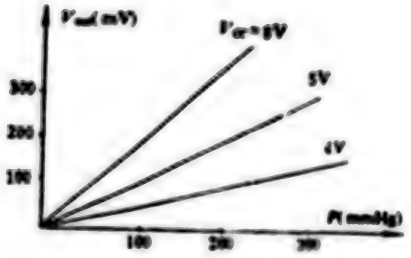

Figure 2. Pressure response curve at different power source voltages

Relationship between of the transducer sensitivity temperature coefficient (TCS) and the power source voltage can be derived by differential calculation by formula (2) and the curve is illustrated in Figure 3.

From Figure 3 it can be seen that when V_{cc} = 5V, the TCS of the circuit can be compensated to zero.

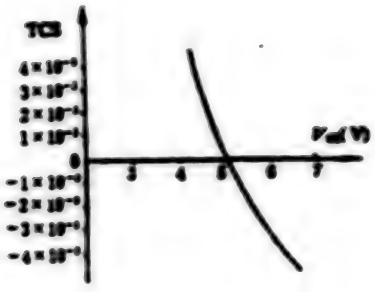

Figure 3. Relationship of sensitivity temperature coefficient and power source voltage

The chip temperature signal which the diode D_3 supplies to the external circuit induces a change of approximately 1.8 mV per degree, and through an external compensatory circuit can compensate for the transducer's zero temperature drift.

Below we discuss the important characteristics of the transducer.

1. Sensitivity

Sensitivity $S = V_{out}/P$, and from formula (2) it can be seen that the magnitude of S is roughly in direct proportion with V_{cc}^2. As V_{cc} increases, S also clearly increases, but considering the influence of temperature characteristics, when V_{cc} = 5V, S = 1000 μV/mmHg, see Figure 4.

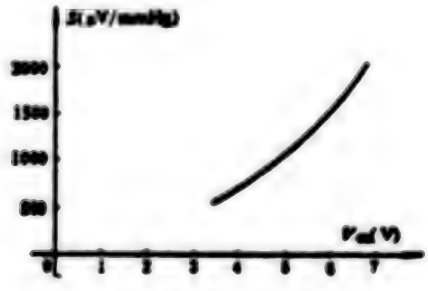

Figure 4. Relationship of sensitivity and voltage supplied

2. Precision and frequency response characteristics

Many users are accustomed to using precision δ to measure the performance of a transducer. The precision indicators are the three root-mean-squares of linearity δ_1, lag δ_2 and repetitivity δ_3

$$\delta = \sqrt{\delta_1^2 + \delta_2^2 + \delta_3^2}\ .$$

Linearity is the difference between the calibration curve of the measured input/output and its theoretical fitting line. The linearity of the integrated pressure transducer is very good and has an error better than 0.5 percent of its magnitude.

The lag expresses the degree to which the input/output curve of the transducer in the forward and reverse position is not uniform. The repetitivity expresses the degree to which the characteristic curve of the transducer obtained when the input quantity changes many times in succession in overall magnitude in the same direction is not uniform. Since the error of lag and repetition of the chip itself is very small, the error is mainly caused by packaging. The CY series products use soft packaging so that packaging stress is reduced, and after aging technology was adopted, the lag and repetitivity both were smaller than 0.5 percent. Thus,

$$\begin{aligned}\delta &= \sqrt{\delta_1^2 + \delta_2^2 + \delta_3^2} \\ &= \sqrt{(0.5\%)^2 + (0.5\%)^2 + (0.5\%)^2} \\ &= 0.87\%\end{aligned}$$

and after grading, the optimum is less than 0.2 percent.

If what is being measured is non-corrosive gas or liquid under constant temperature, it is not necessary to use pressure transmission medium, but the substance to be measured can come in direct contact with the silicon ring. At this time, the precision of the transducer can reach better than 2 parts per 10,000, and frequency response can be better than 20 kHz.

3. Temperature characteristics

Temperature characteristics refers to the two parameters of sensitivity temperature drift and zero point temperature drift. From Figure 1 it can be seen that the characteristic that the forward voltage drop of diodes D_1, and D_2 and the forward voltage drop of junction be of T_1, and T_2 rises and falls with the temperature can be used to raise the voltage of the actual power supplied by the bridge and the working current of the difference transistors, compensating for the resistance sensitivity and the influence of the triode transconductance rising and falling with the temperature. When the power supply voltage is high, the compensating function of the diode is not enough and the entire circuit carries a negative temperature coefficient; when the power supply voltage is low, the compensating function of the diode is too strong and the entire circuit carries a positive temperature coefficient. We have assumed that when V_{cc} = 5V, TCS<1 x 10^{-4}/°C.

To control the zero point temperature drift, we used D_3 to access a chip temperature signal, and compensated for the zero point temperature drift through an external compensating circuit so that the zero point temperature drift control is within 0.2 percent.

4. Power consumption and imbalance

In Figure 1, the current across the bridge $I_0 = (V_{cc} - V_{be})/R$, the difference transistor total current $I_c = (V_{cc} - 5V_{be})/2R_5$, total power consumption current $I = I_0 + I_e$. It is already known that $R_1 = R_2 = R_3 = R_4 = R = 2.5k\Omega$, $R_5 = 6k\Omega$, $V_{be} = 0.6V$, the power consumption curve measured is illustrated in Figure 5.

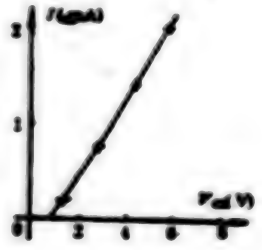

Figure 5. Relationship of power consumption current and supplied voltage

The transducer's offset voltage comes mainly from the asymmetry of the bridge resistance. If a bridge resistance deviates from the balanced ΔR, i.e., $R_1 = R - \Delta R$, $R_2 = R_3 = R_4 = R$, then the resulting bridge output offset voltage is

$$V_{os} = \left(\frac{R}{2R-\Delta R} - \frac{R}{2R}\right)(V_{cc} - V_{ss})$$

$$\approx \frac{\Delta R}{4R}(V_{cc} - V_{ss})$$

and when $\Delta R/R = 0.5$ percent and $V_{cc} = 5V$, $V_{os} = 5.5mV$.

Summarizing the above, compared with other pressure transducers, the CY series products have the following advantages:

1. They have very high sensitivity and ability to resist interference. Full amplitude output is several hundred mV, output sensitivity reaches 1000 mV/mmHg, [illegible] more sensitive than ordinary solid pressure resistance or tensed wire transducers.

2. They have high measurement precision.

3. They have very good temperature stability.

4. It is miniaturized: the chip measures 2.4 x 2.4 mm, and the diameter of the packaged transducer is ϕ10 mm.

5. The demands on back signal circuit are simplified.

6. They are low in cost.

The applications are briefly discussed below.

1. Biological pressure gauge

The CY-1 is a biological pressure transducer. Attached to a PTM-1 gauge it can measure pressure in the circulatory system of the human body and cranial, esophageal, cervical, and bladder pressure. It is easy to use in clinical diagnosis and is stable in performance. Comparing the primary technical characteristics of the CY-1 biological pressure transducer with the U.S. Gould Company's P-23 biological pressure transducer, in 11 primary technical parameters, it is largely superior to the P-23, as is shown in the table.

Technical characteristic	CY-1	P-23
Magnitude of pressure	-50 ~ +300mmHg	-50 ~ +300mmHg
Sensitivity (5V DC power)	1000μV/mmHg	25μV/mmHg
Sensitivity temperature coefficient	1×10^{-4}/°C	2.7×10^{-4}/°C
Linearity	0.5%	0.5%
Delay	0.5%	0.5%
Bridge resistance	2500Ω	350Ω
Zero point temperature coefficient	2×10^{-3}F.S./°C	0.7×10^{-3}F.S./°C
Weight (not including leads)	9g	45g
Length (main body)	30mm	56mm
Diameter	13mm	18mm
Frequency response characteristics	≈240Hz	≈200Hz

2. Medical pulse gauge

Attaching a simple impedance matching circuit behind the CY-2 transducer and connecting it to an electrocardiogram or recorder makes it possible to measure a pulse and dynamic pulse pressure. It can stimulate the traditional pulse-taking methods of Chinese medicine and output the characteristics of 28 human body pulses.

3. Differential pressure flow gauge

Using the CY-3 differential pressure transducer and restrictor devices it is possible to create a differential pressure flow gauge, which can measure the volume of flow of various liquids. It has the advantages of simplicity, reliability and high degree of precision.

4. Micropressure gauge

Using a CY-4 micropressure transducer, one can measure pressure within the 0-100 mmH_2O range, providing a modernized measuring technique for micropressure measurements in scientific research.

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APPLIED SCIENCES

NEW DT^{2}L SYSTEM OF LARGE-SCALE INTEGRATED CIRCUIT DESCRIBED

Beijing DIANZI KEXUE JISHU [ELECTRONIC SCIENCE AND TECHNOLOGY] in Chinese
No 12, 10 Dec 84 pp 8-11, 18

[Article by Li Yanhong [2621 1750 7703]]

[Text] This article presents a simplified gate circuit and trigger based on existing TTL circuits to create a new series. It is not only suited to China's existing technological level and package cooling technology, but also improves integration and speed and provides experimental proposals for developing China's own medium and large scale integrated circuit series.

New Simplified Gate Circuits

1. NAND Gate

The simplified NAND gates which are popular in China and abroad at present are illustrated in Figure 1. Of the circuits in Figure 1, (a) has the fewest components, but its ability to resist forward interference is very weak and thus it is suited only for internal integrated circuits. The others can be used as input buffer circuits, but each has its shortcomings: although there are few components in (b), the output low level is high and does not match with the built-in low level circuit; (c) has a high low level output and there are also more components; although (d) has good performance, it has too many components which will not improve integration.

Can an input circuit be found which can both maintain the noise immunity level of the TTL and also reduce the number of components? This is the new simplified NAND gate presented in this paper and it is illustrated in Figure 2.

From the structure of the circuit illustrated in Figure 2(a) and (a'), one can see that this is the circuit illustrated in Figure 1(a) with the addition of one diode D and one triode T_2, it is shown open in Figure 2(a), compared to the circuit in Figure 1(a) the input open gate level improves one junction voltage drop. When the circuit returns from saturation to cut-off state, as illustrated in Figure 2(a'), the current turns into gate current through the R_g base and flows out from the T_1 emitter. The load stored in T_3 base region is drawn out by T_1 and T_2. The key here is that T_2 is different from T_1. When the input jumps from high level to low level, the base no longer injects

current. It can maintain the reverse current channel because the load stored by bc junction of T_2 makes the be junction open so that T_2 conducts and reverses the load stored in T_3 base, and once the load stored in the T_2 base area has been expended, T_2 cuts out, and if the load in T_3 has been all reversed before T_2 cuts out, it accelerates the closing process of T_3.

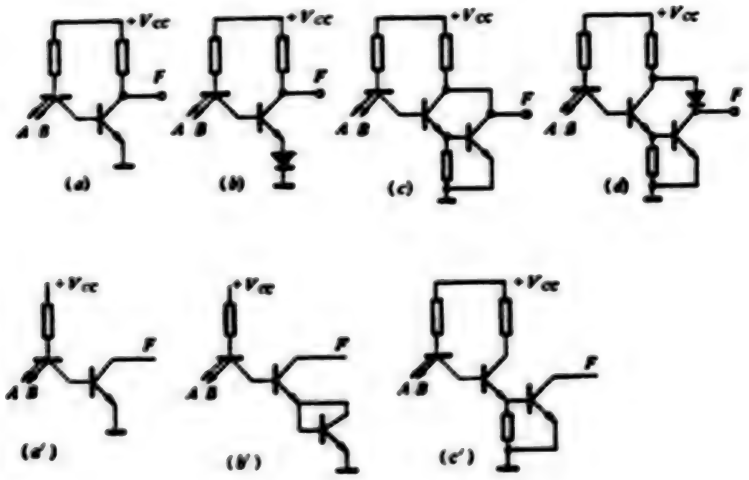


Figure 1. Commonly used simplified NAND gate circuits

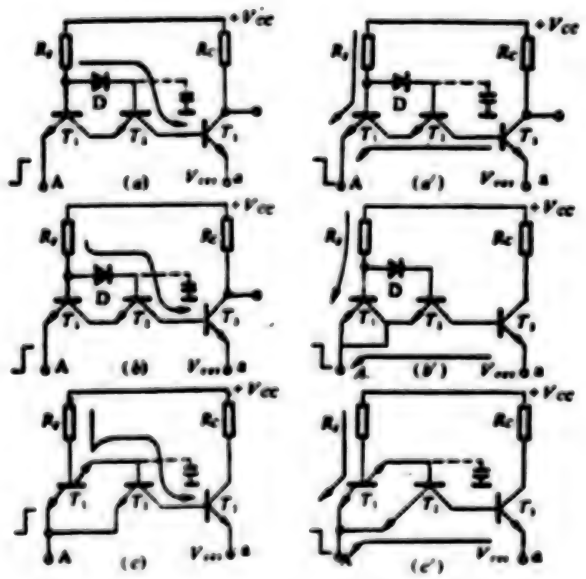


Figure 2. Structural forms of new simplified NAND gates

To further clarify the conducting principles of T_2, we will analyze the charging and discharging process of the two capacitors T_2. Figure 3(a) illustrates the charging process of the bc junction capacitor when the T_2 base is driving. The p and n semiconductors on both sides of the pn junction may be equivalent to the two plates of a capacitor, and the space-charge layer between the pn junction (the part in AB or ab) is equivalent to the dielectric between the plates.

When a high level input, the current flows into the T_2 base from outside through R_g and D, so that the base area is charged, but be junction has not yet conducted it. At this time, the capacitor C_{bc} is charged. It is implemented though changes in the thickness of the space-charged layer, that is, the hole in the p area enters the A side of the space-charged layer, and the electrons in the n area enter the B side of the space-charged layer, thus making the thickness of the space-charged layer smaller and the charge is collected on the reduced area. The charge of the current is illustrated in the figure. When the current charged is sufficient, it makes T_2 enter an amplified state of reverse use, and this amplified current is good for driving the base of T_3.

At the moment that the input changes from high level to low level, as when the input changes from 3.6V to nearly 1.4V, the be junction of T_2 goes from reverse biased to nearly zero biased, and the charge current at this time is supplied by the current through R_g and D. As T_1 conducts, the charged current becomes smaller. And when the input is as small as 1.4V, the charge current of the be junction capacitance of T_2 can no longer be supplied by the power source, but the capacitance of the bc junction is mainly replaced by diffusion capacity releasing the charge accumulated when it was conducting forward. At this time C_{bc} discharges, and at the same time the junction capacitance C_{be} of junction be discharges, i.e., the hole stored in bc junction enters the b side of the be junction's space-charged layer, and the electrons enter the a side, thus the thickness of the space-charged layer becomes smaller, changing from ab to a'b', i.e., the be junction conducts. When this conducting current is sufficient it puts T_2 into the forward amplification state, and at this time, the thickness of the bc junction's space-charged layer becomes greater, changing from AB to A'B', and the bc junction is in the reverse state. Conducting T_2 reverses the T_3 base area charge.

To observe the influence of the stored charge of the bc junction of T_2 on reversing the stored charge of T_3, we carried out an experiment on the circuit illustrated in Figure 4(a). The T_2 in this circuit was a f_T>200 MHz fast transistor, the output waveform is illustrated in Figure 4(b). The experiment showed that when T_2 is a high speed transistor, the capacitance of the collector junction is small and the base area storage charge is not sufficient, reversing the T_3 charge is not an advantage, because the output waveform declines before it has peaked. If a capacitor or diode is added to the bc junction of T_2 or if T_2 is changed to a low f_T transistor, such as 3DKA, then the output waveform is normal, as illustrated in Figure 4(c). Clearly, it demands that the capacity of the bc junction be small, and thus when the domain is designed, this problem should be taken into consideration, i.e., it should be designed with multiemitter transistors and make the f_T a little lower.

a. T_2 transistor base driven
b. T_2 transistor base not driven
c. C_{bc} charge current
d. C_{bc} discharge current

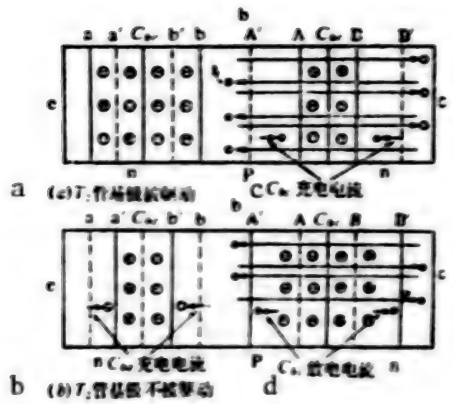


Figure 3

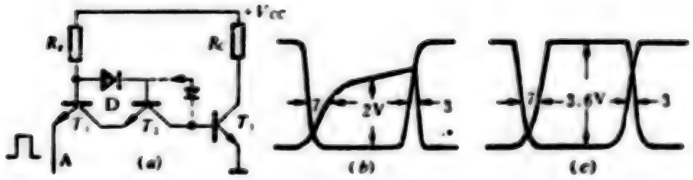


Figure 4

Table 1

V_d(V)	T_{1b}(V)	T_{1c}(V)	T_{2b}(V)	T_{2c}(V)	T_{ac}(V)
4	2.2	1.56	1.47	0.8	0.2
2	2.2	1.56	1.47	0.8	0.2
1.5	2.2	1.50	1.42	0.8	0.2
1.4	2.2	1.50	1.42	0.8	0.2
1.3	2.0	1.35	1.30	0.76	3.4
1.1	1.84	1.18	1.18	0.67	4.8
0.8	1.56	0.85	0.81	0.4	4.9
0.6	1.30	0.65	0.65	0.2	4.9
0.3	1.18	0.4	0.4	0	4.9

Now we will discuss the function of the diode D. Initially, the aim of adding the T_2 was to improve ability to resist interference, and the introduction of D ensured improvement of the ability to resist interference when compensating for a voltage drop from increasing the input terminals by one junction. D plays a capacitance role at the instant that the input changes from high level to low level. At this time, D changes from forward biased to reverse biased. From the polarity of the junction capacitance one knows that in the process of going from forward biased to reverse biased it can draw off part of the charge stored in the T_2 base area, and can also draw off a small part of the stored charge of T_3. For the charge of the T_2 base area to leak in the D circuit is not an ideal situation, thus in design, we did our utmost to make the capacitance of D smaller so that its stored charge would be small, the reverse biased state could be rapidly restored and stop the reverse action.

To discuss the performance of this circuit in more detail, below we have plotted the necessary test data. The electrical potential of the experimental circuit illustrated in Figure 5 at various parameters are given in Table 1.

From the table it can be seen that at a static open gate level of 1.4V, which shows static anti-interference performance.

The waveform in Figure 6 shows the time characteristics when R_g = 3KΩ, R_c = 0.4kΩ, and when T_2 is a 3DKA.

In addition, we carried out experiments on dynamic anti-interference and time delay characteristics with different combinations of parameters. The results show that performance is very good. With different parameters, the increase time was (5-7)ns but the decrease time was (3-5)ns. Under ordinary conditions, the increase time is 7ns, and the decrease time, 5ns. Compared with the simplified circuit in Figure 1(a), under the same parameters, the time characteristics are all the same, which means that there are advantages to adding T_2.

The structure given in Figure 2(b) and (b') further improves the reverse ability of the T_3 stored charge. It can be seen that at this time, the collector of T_1 doesn't have much importance, thus the actual structure which was further simplified and adopted is the one in Figure 2(c) and (c'). Here we got rid of the connection of the T_1 collector and connected the T_2 emitters directly to the T_1 emitters, and replaced one be junction of T_1 with diode D, to fully ensure that the anti-interference input demands would be realized.

Now, a new simplified NAND gate has been produced. Since T_1 essentially functions as a diode, "AND" logic is carried out by a "diode", therefore it was termed a DT^2L circuit. The first "T" refers to T_2, thus distinguishing it from the DTL and TTL series.

The DT^2L element circuit together with other element circuits can form a new circuit system, which demonstrates that it is very flexible in its logic applications. In order to simplify it, here we will cite as an example only an exclusive OR gate and AND-OR-NOT gate circuits which use it. Figure 7 illustrates an exclusive OR gate, with logic form $F = \overline{a\bar{b} + \bar{a}b}$ and Figure 8 illustrates the AND-OR-NOT gate, with logic form $F = \overline{ab + cd}$.

Summarizing the above, this new element circuit has the following characteristics: 1. Powerful ability to resist interference (1.4V), 2. high speed (can reach 5ns), 3. high integration (there are only 4-5 simple gate components), 4. low power consumption (1-2 energy consumption resistance), 5. powerful logic application flexibility (may form a series of circuits).

2. AND Gate

Common AND gates are illustrated in Figure 9. They all exist as independent output units. When they are used in LSI circuits, clearly there is a multiplicity of components which demands simplification. We can imagine implementing the "AND" logic part of a circuit in a standard TTL NAND gate, and have extracted it as illustrated in Figure 10(a). It is an input gate. It can be seen that this is a most simplified AND gate.

This circuit not only can be used in an LSI circuit to carry out the AND gate functions, but also has an extremely high transmission speed. Figure 10 also provides the waveform displayed on a high speed oscilloscope. It can be seen that the effective part of the output overlaps the input waveform, requiring almost no transmission time and this is very encouraging.

The reason this circuit has such a fast transmission speed is because on the margin there is capacitance jump partial pressure. The magnitude of the jump is determined by the ratio of C_1 and C_2 (C_1 is the distribution capacitance between the collector and the emitter and C_2 is the output capacitance). If $C_1 > C_2$, then the magnitude is large and may be close to the value of E; otherwise, it is small. If C_1 is large, the area of the transistor is large and when the integrated circuit chip is designed, it is handled according to the multiemitter transistor core.

In experiments we measured the magnitude of the jump as 2.6V, dropping 0.1V each time it went through a transistor up to 11 levels (open gate level of 1.4V) consecutively, but actually it could only be transmitted up to 6 levels, primarily because there was some loss of power (including resistance) in transmission from level to level, so it was impossible to create ideal conditions for the capacitance jump partial pressure. Nevertheless, the characteristics of this transmission are useful. In addition, since consecutive transmissions make the low level accumulate, at a certain point it will cause an error, and thus in actual use at the appropriate level the low level should be restored and some of the overall flow to the signal source should be split. This phenomenon is not encountered often, but it should be noted in the design of high-speed carry link circuits.

This characteristic of high speed transmission of high level not only exists in the above described AND gate, but also exists in the exclusive-OR gate in Figure 7, and therefore also exists in the DT^2L circuit series, thus in the logic design of functional blocks, the advantages of this circuit should be exploited as much as possible so as to achieve a higher speed.

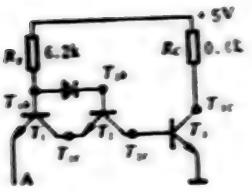


Figure 5.

Figure 6.

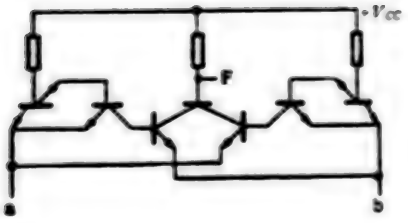


Figure 7. Exclusive-OR gate

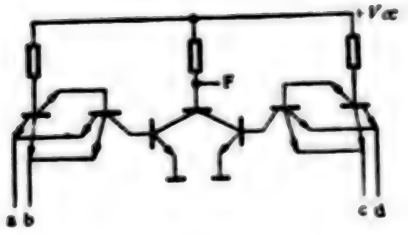


Figure 8. AND-OR-NOT gate

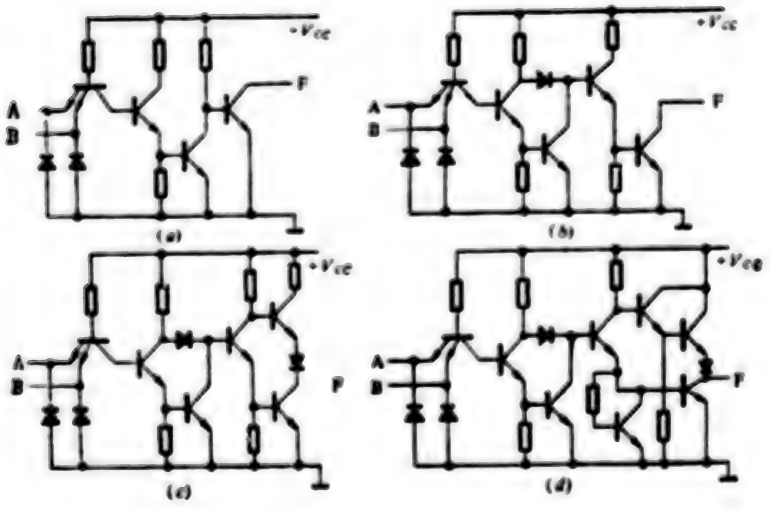


Figure 9. AND gate circuits

Advances in the D Trigger

The logic and circuitry of the common D trigger are illustrated in Figure 11 (a) and (b). This circuit has already been simplified, but the logic levels still maintain their original form. From the perspective of applications, the D trigger input generally should be equipped with a channel conversion switch, generally implemented by an AND-OR-NOT gate, thus the trigger's logic levels would be 5, and if the advanced D trigger as illustrated in Figure 12(a) and (b) is adopted, the logic levels will be commensurately reduced to 3 levels, which would also improve the repetition frequency of the trigger.

In principle, there are no essential changes in this circuit, but there are new changes in its logic circuit and circuit structure. Its working process is described below.

When M_t is at low potential, C and B output are high potential, and A gate is ready to accept the signal; when D_t input is "1", the forward transient jump relays the "1" to A almost immediately.

When M_t is high potential, C output is low potential, then this makes E output high potential, i.e., Q is set to "1". At the same time as this, through a maintenance circuit, C's low potential cuts off A gate and maintains its high potential. Here C gate's obstruction circuit of D gate is eliminated because A's high potential has already performed this function. It is also necessary to point out that at this time B output is low potential, and of necessity makes the arrival of this low potential later than the entry into force of A's maintenance potential. For this reason, making the resistance of B gate a little greater meets the needs of this delay. When D_1 input is 0, due to the negative transient jump, the 0 is very quickly relayed to A, and at the same time, the low potential at A also obstructs C gate. When M_t high potential arrives, D outputs low potential, then makes F output high potential, and E output low potential, i.e., Q is set to 0. In addition, since B outputs low potential, it also maintains the low potential of A.

From the above analysis we can see that the 'A' gate level actually may not occupy a logic level. Moreover, the addition of an input switch in the design is adding the signal to the emitter creating the conditions for a transient jump, thus this is equivalent to eliminating two logic levels. Experiments indicate that the speed is clearly improved.

Summarizing the above, the introduction of the new simplified circuit not only improves speed, but also improves integration. This is the advantage of the improved D trigger and when used to make a medium-scale register components, its superiority can be even further exploited.

The range of applications of the simplified circuit is very broad. Not only can it be used to build special use circuits, but also can systematically form a series of logic circuit components, such as four-bit function generators, eight-bit counters, eight-bit buffers, nine-bit odd-even checkers, four-bit channel shift switches, four-bit comparators, twin two-bit decoders, encoders, and shifters. All of these devices are of the DT^2L series. Due to limitations of space, we will not cite them one by one.

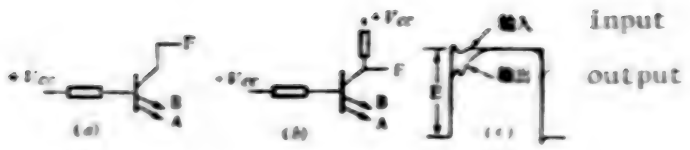


Figure 10. Simplified AND gate circuits and waveforms

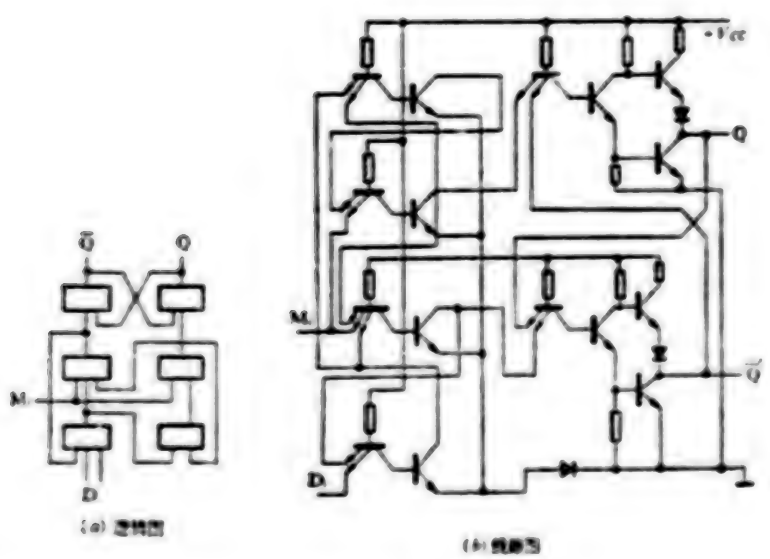


Figure 11. Commonly used D type triggers

a. Logic map
b. Circuit diagram

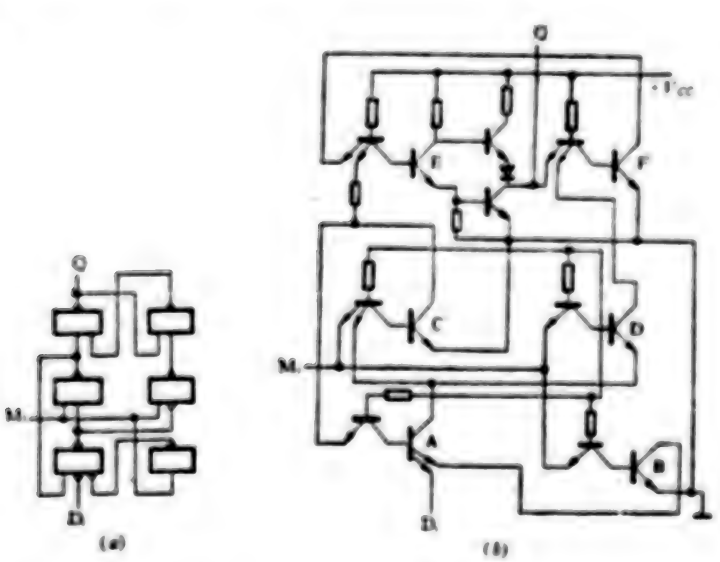


Figure 12. Improved D-type trigger

Conclusion

The basic gate circuit and sequence circuit of this circuit system was proposed a long time ago, and throughout a great deal of experimental and design work has been done with a number of comrades. Comrades of the Shanghai Radio Plant No 19 did technological experiments, and obtained excellent results. I believe that in-depth research and development of this circuit system will play a unique role in the development of China's integration technology.

8226/12712
CSO: 4008/192

APPLIED SCIENCES

ADMITTANCE OF RECTANGULAR WAVEGUIDE OF SLOT ARRAY MEASURED

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 7 No 3, May 83 pp 227-231

[Article by Li Zhixin [2621 4249 2450], Xi'an Electronic Technology Application Institute: "A Simple Method for Measuring the Admittances of Slot on H-plane of Rectangular Waveguide"*]

[Text] I. Introduction

The serial feed waveguide H-plane slot array antenna is a widely used antenna type. The relationship between the waveguide slot conductance and the geometrical dimensions of the slot is the foundation for designing this type of antenna and the frequency characteristics of the slot admittance is an indispensable basis for analyzing the antenna's frequency characteristics. Although the formulas for theoretical analysis can be applied in designing a waveguide slot array antenna,[1] there are some irregularities between the results obtained and the actual situation; therefore, before design, the conductance of the waveguide antenna is measured. Because the conductance of a single slot is rather small, it is difficult to measure accurately and in addition, there is coupling between the slots, thus people generally measure the slot conductance of many (at least 20) slots in the array. Generally the method of measuring the S parameter is used, i.e., measuring the shift of the wave node point and finding the conductance through plotting. This method of measurement is extremely tedious and accurate is hard to guarantee. Some others use the traveling wave power method,[2] but it only gets the conductance at the harmonic frequency. We have yet to see any reports of a simple and direct method of measuring the frequency characteristics of slot admittance. To analyze and predict the frequency characteristics of a serial feed waveguide H-plane slot array antenna and improve the antenna's broad-band performance, this paper proposes an easy, computer-aided method of measuring the admittance frequency characteristics in a slotted array and presents the results of measurement. From the results it can be seen that the frequency characteristics of slot admittance are regular.

*Received 27 Jul 83; finalized 11 Jan 84.

II. Propagation Characteristics of Waveguide H-Plane Slot

As illustrated in Figure 1

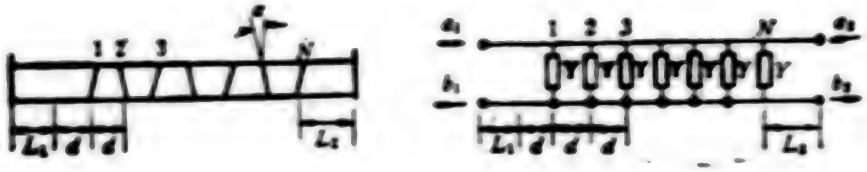


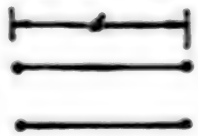
Figure 1 Waveguide H-Plan Slot Array and Its Equivalent Circuit

$$\begin{bmatrix} a_1 \\ b_1 \end{bmatrix} = [T] \begin{bmatrix} b_2 \\ a_2 \end{bmatrix}, \tag{1}$$

in which

$$[T] = \begin{bmatrix} T_{11} & T_{12} \\ T_{21} & T_{22} \end{bmatrix}. \tag{2}$$

The propagation matrix of the equivalent circuit elements is



$$[D]_d = \begin{bmatrix} e^{i\beta d} & 0 \\ 0 & e^{-i\beta d} \end{bmatrix}, \tag{3}$$

$$[T_0] = \begin{bmatrix} 1 + \frac{1}{2} y_i & \frac{1}{2} y_i \\ -\frac{1}{2} y_i & 1 - \frac{1}{2} y_i \end{bmatrix}, \tag{4}$$

$$[T]_i = [D]_d [T_0]_i. \tag{5}$$

The total propagation Matrix of the measured slot is

$$[T] = [T]_{L_1} \cdot \prod_{i=1}^{N} [T]_i \cdot [T]_{L_2}. \tag{6}$$

Let

$$y_i = g_i + ib_i, \tag{7}$$

when the total number of slots N>20, the fringe effect can be overlooked, at this time

$$y_i \approx g + ib. \tag{8}$$

Let

$$[T] = \begin{bmatrix} T(1) + iT(2) & T(3) + iT(4) \\ T(5) + iT(6) & T(7) + iT(8) \end{bmatrix}, \tag{9}$$

$$T_{11} = \sqrt{T^2(1) + T^2(2)}\, e^{i \arctan \frac{T(2)}{T(1)}}, \tag{10}$$

and the scattering matrix parameter

$$S_n = |S_n| e^{j\varphi_n}, \tag{11}$$

because

$$S_n = 1/T_n, \tag{12}$$

therefore

$$|S_n| = 1/\sqrt{T^2(1) + T^2(2)}, \tag{13}$$

$$\varphi_n = -\operatorname{arc\,tg} \frac{T(2)}{T(1)}. \tag{14}$$

III. Method for Measuring Slot Admittance

The length L of the object illustrated in Figure 1 to be measured is

$$L = L_1 + Nd + L_2. \tag{15}$$

The phase difference between the slot array and all waveguides of similar length is

$$\Delta\varphi = \varphi_n - \beta L = -\operatorname{arc\,tg} \frac{T(2)}{T(1)} - \beta L, \tag{16}$$

in which

$$\beta = \frac{2\pi}{\lambda}\sqrt{1 - (\lambda/2a)^2}. \tag{17}$$

If we measure $\Delta\varphi$ and $|S_{21}|$ of each frequency, we can solve the group of simultaneous equations eqs (13) and (16)

$$\left.\begin{aligned} |S_n| &= 1/\sqrt{T^2(1) + T^2(2)} \\ \Delta\varphi &= -\operatorname{arc\,tg} \frac{T(2)}{T(1)} - \beta L. \end{aligned}\right\}. \tag{18}$$

Solving this group of simultaneous equations one can find the slot conditions g and admittance b. The g and b found are the admittance of each slot when coupled, i.e., the admittance of the array.

IV. Example of Measurement and Results

Our test sample was a BJ-100 waveguide with 30 slots open on the H-plane. Slot inclination was the same, interval was d=0.56λ_0 (as illustrated in Figure 1), and resonated to frequency f_0. We used a microwave network analyzer within a frequency range of f_0±500 MHz and measured the $|S_{21}|$ and $\Delta\varphi$ of the test sample at α = 10°, 12°, and 17°. The results are illustrated in Figures 2(a) and (b). Further, with the help of a computer we solved the binary simultaneous equation group (18), and obtained the values of g and b at different frequencies, as illustrated in Figures 3(a) and (b). On the basis of the measurement and

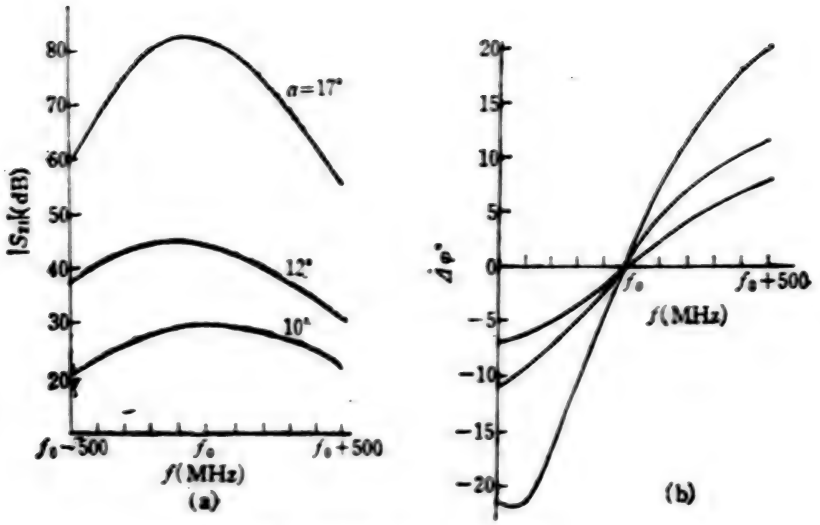


图 2 实测的 $|S_{21}|$ 和 $\Delta\varphi$ 值

Figure 2. Test S_{21} and $\Delta\varphi$ values

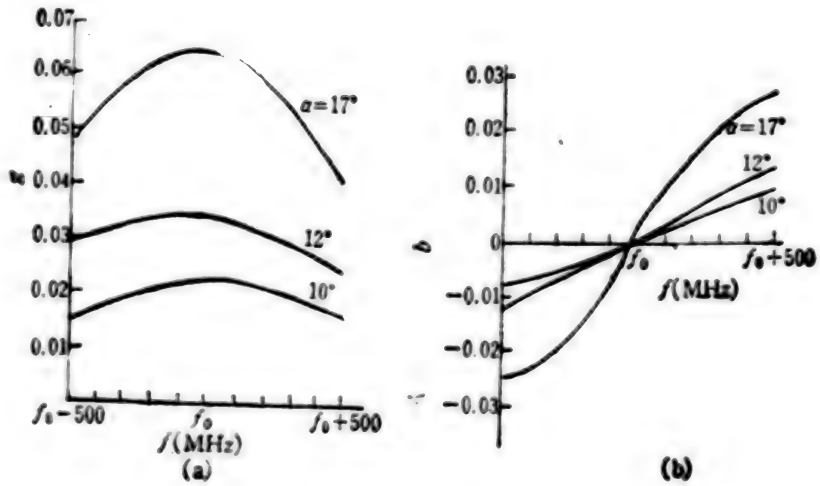


图 3 测量结果

Figure 3. Measurement results

computation results we can draw the curve of the relationship of the parameters and ℓ as illustrated in Figures 4(a), (b), and (c). Thus we could write approximately the relationship of g and b with the frequency shift $\frac{\Delta f}{f_0}$-- and

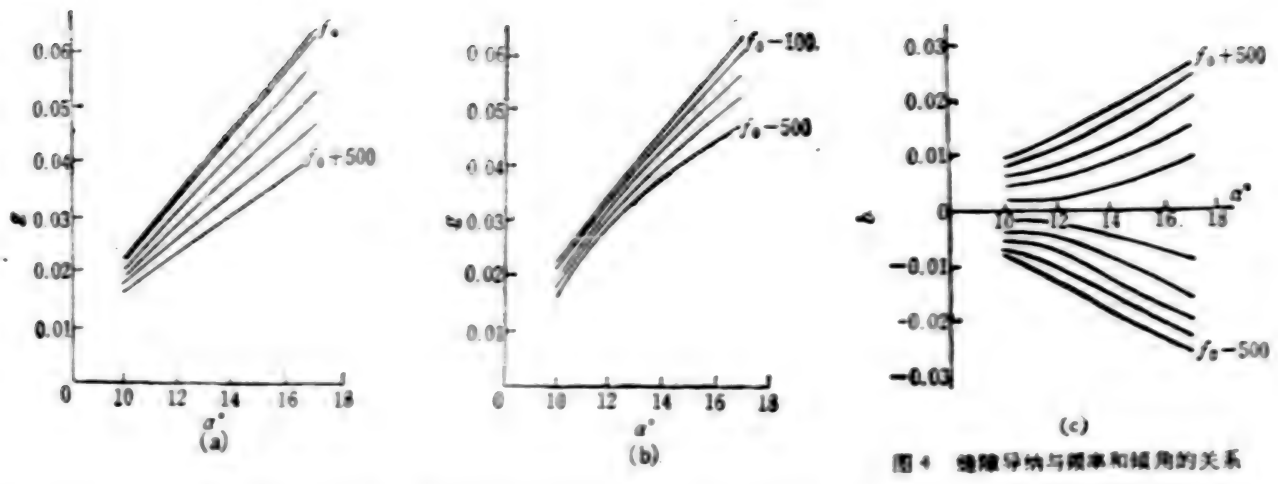


图 4 缝隙导纳与频率和倾角的关系

Figure 4. Relationship of slot admittance frequency and inclination angle

angle of inclination α.

$$g\left(\frac{\Delta f}{f_0}\right) = G(0)\sin^2\alpha - F\left(\frac{\Delta f}{f_0}\right), \tag{19}$$

in which

$$F\left(\frac{\Delta f}{f_0}\right) \approx \begin{cases} 0, & \left|\frac{\Delta f}{f_0}\right| \leqslant 1\%; \\ 0.000675\alpha^\circ \left|\frac{\Delta f}{f_0}\right|, & \left|\frac{\Delta f}{f_0}\right| > 1\%; \end{cases} \tag{20}$$

$$b\left(\frac{\Delta f}{f_0}\right) \approx 0.002\left(\frac{\Delta f}{f_0}\right)\alpha^{\circ 3}(1 + \lg^2\alpha). \tag{21}$$

when the frequency is the slot harmonic frequency,

$$g(0) = G(0)\sin^2\alpha, \quad G(0) \approx 0.7695; \tag{22}$$

$$b(0) = 0. \tag{23}$$

the above results provide the basis for analyzing and predicting the frequency characteristics of the slotted array antenna. It must be pointed out that because the element distance d and the slot width are different for different slotted arrays, the coupling is also different and thus the constants in eqs (20), (21), and (22) are also different. So that the measurement results will conform better to the actual situation, care should be taken when measuring to ensure the same coupling situation when in use.

V. Conclusion

The tests prove that this method is simple and saves time. For design of slotted antennas, the precision of the measured results is sufficient for design of slotted antennas and provides a basis for analyzing and predicting the frequency characteristics of antennas.

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8226/12232
CSO: 4008/1038

APPLIED SCIENCES

DESIGN OF OPTICAL DETECTOR, RECEIVER DISCUSSED

Dalian DALIAN GONGXUEYUAN XUEBAO [JOURNAL OF DALIAN INSTITUTE OF TECHNOLOGY] in Chinese Vol 24 No 3, Sep 85 pp 121-124

[Article by Li Guoxiang [2621 0948 4382] and Xu Jingde [1776 2529 1795] of the Teaching and Research Section of Information Engineering at DIT: "Design of Optical Band Signal Detector"; manuscript received on 6 September 1984]

[Text] 1. Duality of Optical Band Signal Receiving Equipment and Radio Receiving Equipment

An optical band signal receiving unit is, in many aspects, similar to a radio receiver system. It is composed of a photodetector, receiver, and terminal. A radio receiver unit includes an antenna, receiver, and terminal. They are also similar in major technical areas such as sensitivity, frequency response (including selectivity), non-linear distortion, signal to noise ratio and mis-code ratio. Based on these facts, the duality of an optical band signal receiver unit and a radio receiver unit is presented in this paper. The following dualities exist: photodetector versus receiving antenna, receiver versus receiver, and terminal versus terminal. Based on these dualities, a photodetector is considered as a receiving antenna. Then, an optical band signal receiving device can be modelled as a radio receiving device. Thus the design theory for radio receiving equipment can be used for optical frequency band signal receiving equipment.

Presently most people use PIN silicon photodiodes and APD avalanche photo-diodes as photodetector components. The diode itself is equivalent to a constant current source with a parallel capacitor. Including the load, a constant current source with a parallel admittance.

Regardless of the mode and operating frequency, a receiving antenna is equiva-lent to a signal voltage source in series with an impendance, or a current source in parallel to an admittance. Based on the equivalent circuit, a photodetector is identical to a receiving antenna.

In terms of its internal structure, a photodetector, in addition to a light sensitive layer, is also equipped with a lens system which is a device of directivity. The maximum current can only be detected in the direction of maximum incidence. This is in analogy with the directivity of a receiving radio antenna and the duality exists.

In a light detecting device, between the photodetector and the receiver, there is an electrical circuit which has the same functions as that in a radio receiving device to suppress interference, limit noise, and select signal. To simulate a radio receiving device or the input circuit, various modes of circuits such as direct coupling and electrical induction (mutual induction) coupling circuits. Figure 1 shows a direct coupling input circuit. C_c is the dc insulating capacitor, L and C are the inductance and capacitance of the resonance circuit whose resonance frequencies are equal to the carrier frequencies R_1 and R_2, and R_3 and C_3 are the biasing elements of the amplifier. Figure 2 shows a mutual induction coupling circuit. A type input circuit, shown in Figure 3, can be evolved from these two types of circuits. L, C_1 and C_2 are in resonance at the carrier frequency.

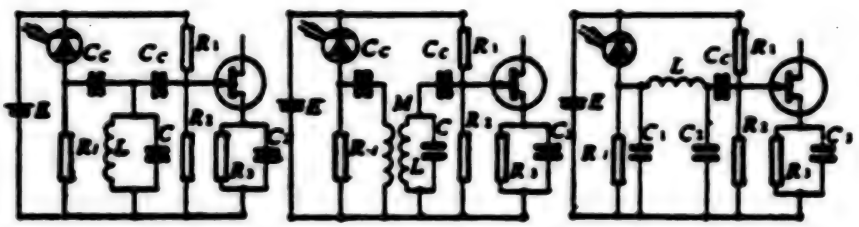

Figure 1 Figure 2 Figure 3

2. Key Issues in the Design of Photodetector and Receiver

Similar to designing a piece of radio receiving equipment, the design of an optical band signal receiver is centered around major technical issues such as sensitivity and frequency response.

The minimum incident light power of the photodetector is the sensitivity P_{oi} of the equipment. It is also the sensitivity of the photodetector. Its relationship with the sensitivity of the photodetector tube S and the sensitivity of the receiver P_{ri} can be derived based on Figure 4. In the figure the current source $I = SP_{oi}$. $_JR_i$ and R_i are the output impedance of the detector. $_JR_r$ and the R_r are the input impedance of the receiver. In the event of conjugate matching, $R_i = R_r$ and $_JX_i = {}_JX_r$. The maximum power received from the detector is the sensitivity of the receiver.

$$P_{ri} = (I/2)^2 R_i = (S^2 P_{oi}^2/4) R_i \qquad (1)$$

We can choose high sensitivity photodiodes in order to ensure the high sensitivity of the photodetector. However, we must notice that a photodiode is a capacitive element which is equivalent to a constant current source parallel to a capacitor. Furthermore, a photodiode is also a source of noise, providing quantum noise. Therefore, a detector comprised of a photodiode and a biasing circuit is no longer a constant current source with a parallel capacitor. Instead, it is a circuit with a current source and parallel resistance and capacitance. In this case, the detector not only provides quantum noise but also thermal noise which is often higher than quantum noise.

In order to ensure the high sensitivity of the receiver itself, it should have a high gain and a low noise index. Hence, we should select a high gain and low noise tube in the first stage to allow the entire unit to have a low noise index. A multi-stage amplifier should be used to achieve higher gain.

As an example, let us study the relationship between sensitivity, noise index and optimal coupling in the type input circuit shown in Figure 5. In the figure, I, C_d and R_i are photodetector parameters and C_i and R_i are the capacitance and resistance of the field effect tube. The remaining symbols stay the same. In the simplified circuit, $C'_1 = C_d + C_1$ and $C'_2 = C_i + C_2$. The resonance frequency of the loop is $f_o = 1/(2\pi\sqrt{LC})$ where $C = C'_1C'_2/(C_1+C_2)$. The transfer function of the input circuit is $H(f) = U_{ri}/I$. Based on the equivalent circuit it is not difficult to determine the transfer function at resonance:

$$H(f_o) = mR_iR_l/(R_l+m^2R_l)$$

where $m = C'_2/C'_1$. When $m = \sqrt{R_l/R_i}$, $H(f_o) = \sqrt{R_lR_i}/2$ is the maximum. Note that $H_{max} = \sqrt{R_lR_i}/2$, then the corresponding $m = \sqrt{R_l/R_i}$ is the optimal couple which is noted as $m_{OPt} = \sqrt{R_l/R_i}$.

The maximum voltage signal at the input end of the first transistor in the receiver using an optimally coupled π type input circuit is

$$U_{ri} = I \cdot H_{max} = SP_{el}\sqrt{R_iR_i}/2 \qquad (2)$$

From the point of maximum transfer, the photodetector can provide the maximum output if the coupling is maintained. From the viewpoint of minimal noise index, this coupling is also the best.

Figure 4

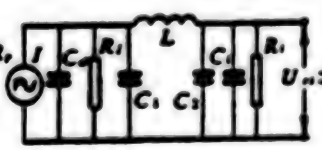

Figure 5

Figure 6

Figure 6 shows the equivalent noise input circuit where $I_d^2 = 2qI_oB$ is the dark current noise generated by the photodetector, $I_\ell^2 = 4KTB/R_\ell$ is the thermal noise generated by R_ℓ, $I_g^2 = 2qI_GB$ is the grid current noise of the field effect transistor and $U_n^2 = 4KTB \times 0.7\,(1+W)g_m$ is the carrier thermal noise and high frequency noise in the field effect transistor channel. In these equations, I_o is the dark current of the photodetector, q is the electronic charge, I_G is the grid current of the FET, K is the Boltzmann constant, B is the bandwidth of noise, W is the increment due to high frequency noise and g_m is the mutual inductance of the FET.

Usually $I_d^2 << I_i^2$ in PIN and I_d^2 can be neglected in determining the noise index. U_n^2 can be treated as the current sources on both sides of the dotted lines $I_n^2 = Y^2 U_n^2$, where Y is the total admittance. When $R_1 >> 1/\omega C_2^o$ is valid (which usually is), the noise index is

$$F = 1 + (I_g^2 + I_n^2)/I_{io}^2 \tag{3}$$

where I_{io}^2 is the noise at the output. In addition, $I_{io}^2 = m^2 I_i^2$. By substituting I_g^2, I_n^2 and I_{io}^2 into equation (3), we find the following when $I_g^2 << I_n^2$.

$$F_{min} = 1 + 2.8(1+W)/g_m R_i \tag{4}$$

The corresponding $m = \sqrt{R_i/R_i}$ happens to coincide with the coupling at maximum voltage output. Therefore, we can arrive at the following conclusions. The optimal coupling for minimum noise index coincides with that for optimum matching in a π input circuit. Please note that the F_{min} given in equation (4) was obtained by omitting the grid current noise of the FET. If it cannot be neglected, the outcome will be slightly larger. This formula can be used as the lower limit in the design.

The frequency characteristics are considered primarily in the design of the receiver, in analogy to the design of radio receivers.

3. Design and Development of Photodetector and Receiver for Frequency Modulated Signals

The subcarrier wave of the optical communication device for mining applications developed in this work is frequency modulated. The subcarrier frequency is 1 MHz. The bandwidth of the telephone signal is 0.3-0.4 kHz. The modulation index $\beta = 2.5$. The modulated bandwidth B = 22 kHz. The sensitivity of the optical receiving unit is $P_{o1} = -53dB_m$ ($0dB_m = 10^{-3}W$). The voltage of the power source is 6V and the power source is batteries.

The photodetector used is a model 2CU51901D PIN type photodiode. A π type circuit such as the one shown in Figure 3 is used between the detector and the receiver. The optimum coupling index is used. The first stage of the receiver employs a 3DJ9 FET. The main amplifier is a direct amplifying circuit. In addition to the input circuit and frequency discriminator, there are two single coupling loops in the pre-amplifier and the main amplifier, respectively, to ensure the bandwidth and frequency requirements.

From the following given technical conditions that the optical sensitivity of the receiving equipment $P_{ot} = -53dB_m$, S = 0.5A/W for the photodetector and $R_1 = 100k\Omega$, equation (1) shows that the sensitivity of the receiver $P_{rt} = -98dB$. From equation (2) we get that the voltage at the grid of the FET $U_{rt} = 0.395mV$ (the input impedance of FET is of the order of MΩ and 1 MΩ is chosen as a lower limit). The input voltage of the frequency discriminator

U_d = 1V. Thus, the voltage gain of the receiver is 68dB. Because the pre-amplifier is single stage, a two stage main amplifier is used. If the gain in each stage is 23.5dB, the total gain is 70.5dB, which will meet the 68dB requirement. Hence, the gain assigned to each stage is 24dB for ease in practice.

The receiver has four single harmonic loops to ensure the bandwidth and frequency requirements. The frequency distortion coefficient is evenly distributed to each loop. The bandwidth of each loop at 3dB attenuation is B_1 = 50kHz. Q = 20(=1MHz/50kHz) with load, which is easy to materialize with L and C elements.

After testing, the sensitivity and frequency characteristics of the equipment were found to satisfy our requirements. At -13dB optical emission power with 40dB optical fiber attenuation, the reception is satisfactory. The range of communication reached 10 km without a relay station with good reception.

12553/6091
CSO: 4008/1008

APPLIED SCIENCES

DESIGN SCHEME OF 8MM HIGH-POWER COAXIAL MAGNETRON DESCRIBED

Beijing DIANZI KEXUE XUEKAN [JOURNAL OF ELECTRONICS] in Chinese Vol 6 No 1, May 84 pp 259-281

[Article by Chen Mingye [7115 2494 2814], Hongguang Electron Tube Plant of China National Electronic Devices Corporation: "A New Scheme for Designing a 8mm High-Power Pulse Coaxial Magnetron"]*

[Text] 1. Introduction

There have been two opinions on the feasibility of coaxial structure for magnetrons at 8mm wave band. One opinion is that when approaching the 8mm wave band, only an anti-coaxial structure can be used, while another opinion is that a coaxial structure can still be realized at 8mm wave band provided that high magnetic conduction material is employed for the terminal boot, and high strength oxygen-free copper is used for the internal resonant chamber, as well as employing line cutting method to process.

Currently, there is still difficulty in obtaining high magnetic conduction material for use in vacuum and air tight environments. The processing method of line cutting is still primarily employed in scientific research, and there is a certain degree of difficulty for batch production plants. Thus the following conflicts would be encountered when ordinary pure iron DT 8A is used as material for the terminal boot, while the internal and external resonant chamber are made of oxygen-free copperTUL:

(1) Due to the small size of the structure, the magnetic field in the interactive space is below the required intensity; if the distance between the upper and lower terminal boots is to be reduced to satisfy the magnetic field requirement, then there would be restriction from the height of the anode blade and the cathode axial height;

(2) The effective transmission area of the cathode is not large enough. There would be restriction from the axial height if the cathode's effective transmission area is to be enlarged; and

* Received on 27 May 1983.

(3) Both the anode blade and the cylinder wall of the internal resonant chamber are very thin, a situation which not only presents poor mechanical strength, but also poses problems in heat conduction.

In order to overcome the above conflicts, we employ a new design scheme.

2. The design of anode aperture d_a

Kobayashi Daijiro's equation[1] of working voltage line is generally followed in computing the anode aperture d_a for coaxial magnetron in centimeter wave band.

$$d_a = 2N\lambda \sqrt{\frac{U_a}{(1-\sigma)(1884N\lambda B - 4.04 \times 10^2)}} \quad (\text{cm}), \tag{1}$$

where N - number of resonant chamber;
λ - working wave length, cm;
U_a - working voltage, V;
σ - ratio of cathode diameter to anode diameter;
B - magnetic field intensity, GS.

The following problem will surface if the value of d_a computed in equation (1) is to be used to design the internal resonant chamber (i ternal chamber for short) for 8mm coaxial magnetron:

(1) The cylinder's inner diameter of the internal chamber being too small poses a limit on the maximum cross sectional area of the terminal boots. If pure iron DT 8A is used for terminal boots, the maximum magnetic field intensity of interactive space can only reach 8,000 GS, which is a long way from 11,000 GS, the magnetic field strength needed in reality.

(2) The anode aperture d_a being small causes a similarly smaller cathode diameter $d_1 = \sigma d_a$. Now in order to increase the cathode surface area, the cathode axial length h_k has to be increased, and in doing so not only is the distance between the upper and lower terminal boots increased, causing even weaker magnetic field in the interactive space, but it also results in severe space parasitic oscillation at the ends.

Therefore we construct the following hypothesis to substantially increase the value of d_a.

It is well known that the threshold voltage of pth space resonant wave for n mode is determined by the Hartree equation[2].

$$U_{th} = \frac{\omega_0 (r_2^2 - r_1^2)}{2(n + PN)} B - \frac{m r_1^2}{|e|} \left(\frac{\omega_0}{n + PN} \right)^2, \tag{2}$$

where U_{th} - "anode threshold voltage" of the magnetron;
B - magnetic field intensity;
r_a - radius of anode;
r_k - radius of cathode;
n - mode number of oscillation;
p - space resonant wave number;
wn - oscillating angle frequency of the nth oscillation mode;
e - electron charge;
m - mass of electrion; and
N - number of anode resonant chamber.

If the magnetron is to operate at $n = \frac{N}{2}$ mode, P = +1, ie., the positive first space resonant wave, then when compared with the operation at basic wave mode ($n = \frac{N}{2}$, p = 0) under identical anode voltage and magnetic field intensity, the anode diameter can be substantially increased so that the conflict in designing millimeter wave band magnetron can be resolved.

When operating at the basic wave mode, $n = \frac{N}{2}$, p = 0 then

$$(n + pN) = \frac{N}{2}. \qquad (3)$$

When operating at the positive first space resonant wave, n = -n/-2, p = 1, then

$$(n + pN) = \frac{N}{2} + N = \frac{3N}{2}. \qquad (4)$$

When comparing equation (3) and equation (4), it can be seen that if N is only to be substituted with 3N in equation (1), the original design to operate in the basic wave π mode can be transferred to operating at the positive first space resonant wave. Thus the diameter of the anode should be:

$$d_a \approx 2(3N)\lambda\sqrt{\frac{U_a}{(1-\sigma)[1884(3N)\lambda B - 4.34 \times 10^7]}} \text{ (cm)}. \qquad (5)$$

If the value of the millimeter wave is to be put into equation (5), it is obvious that in the equation, inside the radical sign, the denominator's second term is much smaller than the first term, and thus can be ignored, therefore

$$d_a \approx 2.52\sqrt{\frac{N\lambda U_a}{(1-\sigma) \times 1000B}} \text{ (cm)}. \qquad (6a)$$

Converting the unit of U_a to the conventional kilovolt (kV), we have

$$d_a \approx 2.52\sqrt{\frac{N\lambda U}{(1-\sigma)B}} \text{ (cm)}. \qquad (6b)$$

It is apparent that the value of d_a computed according to equation (6b) is much larger than the value of d_a computed according to equation (1). Thus we can solve the design problem of millimeter wave band magnetron that is caused by using the computation equation of centimeter wave band.

3. Determination of the ratio, η of internal and external chamber diameters.

Currently, the value of η of coaxial magnetrons covering C wave band to Ka wave band is generally determined in the range of 0.25 - 0.41[1].

In designing an 8mm wave band pulse coaxial magnetron, we select η = 0.55 - 0.58 mainly for the consideration of:

(1) In order to achieve tuning with TE_{011} mode within the entire frequency band, it is imperative that $\lambda_{col} > \lambda_{max}$ (λ_{col} is the cut-off wave length for TE_{011}, λmax is the maximum resonant wave length within the working frequency band range);

(2) In order to increase the ratio of external chamber storage energy to internal chamber storage energy so as to achieve the effect of stable frequency, we have to design a large L/h_a which is the ratio of the external chamber height L to the axial height of the anode blade h_a; and because L/h_a increases with increasing value of η, thus the value of η has to be maximized.

4. The design of box-shaped window

The box-shaped window for C wave band and X wave band has long been used in a wide range of applications. Nevertheless, can box-shaped windows be employed in millimeter wave coaxial magnetrons? We have performed a great deal of research work on that. Initially, 95 percent Al_2O_3 ceramic tiles were also used as window panes. However, no matter how thin the ceramic tile was made (0.4 mm), the frequency band could only be modulated to $f_c \pm 100$ MHz which obviously failed to satisfy the requirement of frequency modulation for millimeter wave band. Later we used 0.1 mm thick man-made mica sheet as window pane, to achieve an excellent frequency band characteristic for standing wave coefficient 1.1 within the $f_c \pm 1500$ MHz range, thus resolving the issue of realizing broad frequency band modulatable energy transfer window in 8 mm coaxial magnetrons.

5. Conclusion

It is reported that[1] the efficiency of an overseas 8 mm pulse coaxial magnetron SFD-319 was 19.76 percnet, 19 percent efficiency for SFD-315, and 13.9 percent efficiency for SFD-332.

Our 8 mm wave band pulse coaxial magnetrons constructed with the new design scheme have achieved an efficiency of 20.2 percent. They have been turned over to users, and certified by China National Electronic Devices Corporation.

Deep appreciation is extended to Qian Weizong [6929 1983 1350], associate professor in Electronic Engineering Department of Xian Jiaotung University, who gave consultation in the research and construction of the magnetron, as well as detailed verification and revision on this paper.

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APPLIED SCIENCES

ENGINEERING STANDARD OF MOS MEMORY MODULE

Beijing JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT] in Chinese Vol 21 No 11, [Nov] 84 pp 30-36

[Article by Chen Jingdong [7115 4842 2639], Zhu Zucai [2612 4371 2088], and Xu Zhongquan [1776 0112 2938]: "Engineering Standard of MOS Memory Module*"]

[Excerpts] (Note: Mere theoretical feasibility and correctness in principle, without scientific engineering design and rigorous implementation, not only make it impossible to create a machine which is easy to produce, low-priced, and performs dependably, but may even lead to catastrophic results. In the past, we have had many lessons in this regard. In this connection, the Information Storage Technology Group of the China Computer Society at its 1982 conference in Suzhou proposed increasing scientific activities in the area of engineering reliability, and asked the East China Computing Institute and the North China Computing Institute to jointly draft a paper on engineering standards of the MOS memory module, and to organize a discussion, held in February of 1984 at the Jiangsu Shazhou [Computer] Storage Plant, presided over by Comrade Chen Jingdong of the East China Computing Institute, with the participation of specialists from concerned plants and institutes all over the country. According to the results of the discussion, Comrades Zhu Zucai and Xu Zhongquan revised the standard, and it is being published by the editorial department of JISUANJI YANJIU YU FAZHAN [COMPUTER RESEARCH AND DEVELOPMENT]. It will further stimulate China's production and development of MOS memories. It will not only provide something to go by in the research and manufacture of memory units, but will also enable memory users to monitor and urge producers to carry the standard through. From the standpoint of developing China's computer industry, the study group will continue from now on to launch activities regarding engineering reliability. In addition, we hope concerned units will carry on more research tasks in this area, to improve the level of engineering design theories and related technologies, and we hope publishing departments will publish books in this area.--Huang Yuheng [7806 3768 3801])

*Article contributed by the Information Storage Technology Group of the China Computer Society.

Preface

Mankind has entered the information society, and information storage is an important technology of the information age. Not only is it needed in computer design, but it is also indispensable in many kinds of electronic control equipment. MOS RAM is already widely used in many different fields. At present, domestic research and manufacture of computers is flourishing. In order to speed up the lead-time cycle of these machines and to enhance their performance reliability so as to promote the development of information storage technology, in February of 1984 the China Computer Society's storage technology group invited experts from concerned units throughout the country to Jiangsu Shazhou [Computer] Storage Plant to hold a meeting to examine and approve an MOS memory module standard, and a draft of the "standard" was approved. It combines the achievements of the past few years of experience in the research and manufacture of MOS memory; the data contained in the "standard" are derived from articles from two conferences on information storage technology and from the practical experience of the units represented by the participating experts. In the process of examining and approving this "standard," they not only took into consideration the present level of research and production in China, but also took note of the level of development of devices in the next few years. According to the principle of combining a scientific theoretical basis with practical needs, they have striven to reach the goal of combining principle and flexibility. But the rapid development of computer science technology has also brought to the "standard" some unavoidable limitations and shortcomings, which should be continuously revised and supplemented later on. But in any case, it has reference value to those in China who are engaged in computer systems engineering design, especially in plants specializing in MOS memories. At present, it will be very effective in the enhancement of the reliability of MOS memory engineering. It may be of use as a reference to the State General Bureau of Standards in working out a standard.

I. General Principles

1.1 This "standard" lists the testing standards and engineering design principles for the research and manufacture of MOS RAM devices; it does not go into the details of the production process.

1.2 Requirements for Testing Instruments:

(1) The voltage drop of the indicator used for DC parameter testing should be sufficiently small. In general, the internal voltage drop should be smaller than 1 percent of the working voltage of the tested loop.

(2) The load-effect of the indicator used for testing voltage parameters should be sufficiently small. In general, the internal resistance of instruments used for voltage indication should be larger than 1 MΩ/V.

(3) The band of oscilloscopes used for testing should be $\geq 1/3$ tr, where tr is the minimum time rise of the tested signal.

(4) Digital voltmeters should be accurate to three decimal places.

(5) The program clock resolution of the testing instrument should be ≤0.5 - 1 ns; for developing and manufacturing memories with a storage cycle larger than 300 ns, the testing resolution can drop to ≤2 ns.

1.3 Power Requirements for Testing:

The stability of stabilized voltage supply used for testing can allow an error of ±2 percent, with ripple voltage not larger than 0.50 percent.

1.4 Conditions for Testing Environment:

(1) All testing operations should be carried out on an electrostatically shielded table. The operator should be grounded.

(2) Testing of electrical parameters should be carried out under normal environmental conditions. Normal environmental conditions: air temperature is 20° ± 5°C, relative humidity 65 ± 15 percent, atmospheric pressure 750 ± 30 mmHg.

(3) Memory devices should be stored in an electrostatically shielded box.

II. Testing of MOS RAM DC Property Parameters and Several Engineering Processes

[. . .]

III. Testing of AC Properties

[. . .]

IV. Selection of Testing Graphs

Functional testing is one of the major testing items for MOS devices, and the selection of testing graphs has a great effect on the quality of the testing results. Different circuits and processes have different sensitivities to testing graphs. Extensive testing has shown that N graphs are more rigorous in testing the address coding portion, N^2 graphs are more rigorous in testing the disturbance coupling between storage cells, and $N^{3/2}$ graphs are between these two. There are many kinds of testing graphs for semiconductor memory devices, and each graph pays particular attention to testing a certain function of the memory device. For example, all "0"/all "1" can only do a preliminary check of the storage function of a memory device, but cannot check for trouble with decoders and storage cells.

[. . .]

V. Aging and Screening of Devices

[. . .]

VI. Memory Module Board Design

The quality of the module board is the key factor influencing the reliability of the memory device, and must be given sufficient attention in the process of development and production.

VII. Special Requirements for the Module Board Production Process

[. . .]

VIII. Testing of Memory Module Board

[. . .]

IX. Considerations of Layout in Medium and Large Size Domestically Designed Memory Cabinets and of Main Board Engineering Design

Printed main boards have the virtues of high assembly density, good electric performance, short production cycle, and the ability to eliminate noise signals arising because of loose wiring, and for these reasons printed main board structure is used at present in the production of all computers. The following are principles of main board production:

9.1 Card Layout:

(1) Data input and output cards should be near error-checking cards.

(2) It is preferable for storage board sequence cards to be near memory modules; if possible, they should be installed in the center of the memory module.

(3) Other cards should be arranged with the shortest possible routing between them.

(4) If conflicts arise in the arrangement of cards, handle them, according to the required degree of time-sequence accuracy, in the order of clock line, pulse line, drive line, potential line, neon indicator circuit lead wire.

9.2 Considerations of Main Board Engineering Design:

(1) The filter system must be perfect, and there should be positions left at both ends of the board for installing filter capacitors.

(2) Consideration should be given to the design of positions on the board for connecting matching resistors. Some need to have matching cards added.

(3) To make every point on the board even in voltage, and to keep the static potential difference small, use the method of lead-in from both top and bottom for the supply line. In a no-load state, the largest potential static difference for the various kinds of power supply must not exceed 5 mV.

(4) When there are not enough bus plane, a bus bar may be added. Connect the power supply from the bus bar directly to the card.

(5) The number of additional ground pins for the board should be determined by reference to the amount of manual routing; in general, the principle to go by is whether there is enough for use.

[. . .]

X. Considerations of Cabinet Ventilation and Power Supply System

(1) To assure good ventilation inside the cabinet, several axial fans should be installed to prevent heat accumulation. Generally, a temperature difference less than 3-5°C at the ventilation opening is desirable. (Note: Exceptions are smaller capacity memories made from a small number of packages, and memories made of low power consumption CMOS packages, because their total power consumption is very small and the temperature rise is low, so self-selected ventilation can be used.)

(2) Memories have a rather large pulse current. In order to improve power feed capability, the total power capacity should retain at least 1/3 of the remaining power. In addition, the power feed line should be short and thick, to ensure a small voltage drop and small amount of induction.

(3) Power supply for peripheral circuits and memory modules should if possible be separate.

(4) In systems assembled from 3-lead power supply MOS devices, the proper sequence should be followed for connecting and disconnecting power supply. Sequence for connecting power supply: first connect -5 V, then +5 V +12 V; sequence for disconnecting: first disconnect +12 V, +5 V, then -5 V. If the -5 voltage should drop, the +12 V +5 V should be automatically cut off in the ms measuring range in order to prevent damage to the MOS device.

(5) The hermetic seal of the cabinet must be satisfactory and the frame should be grounded, to avoid interference from external magnetic fields.

XI. Key Points of Diagnostic Program Design for Memory Modules

Although the MOS devices and module boards have undergone many different kinds of tests before the assembly of the storage module, after the assembly, the necessary condition for ensuring the reliability of the memory is to run complete diagnostic programs through it. The emphasis of the diagnostic programs is not the testing graphs of the individual chips, but problems such as the multi-addressability and disturbance between positions. In general, the following should be taken into consideration: [. . .]

XII. Anti-Interference Testing

When the system is running, artificially create bad conditions, such as a strong electromagnetic field, power disturbance, ray interference, etc. Specialized equipment may be used for testing, or if none is available, the following simple methods may be used to test reliability: [. . .]

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APPLIED SCIENCES

APPLICATION OF MICROCOMPUTER IN COMPOSING, EDITING NEWSPAPER

[Dalian DALIAN GONGXUEYUAN XUEBAO [JOURNAL OF DALIAN INSTITUTE OF TECHNOLOGY] in Chinese Vol 24 No 3, Sep 85 pp 133-136

[Article by Zuo Fengxian [1563 7685 6343] and Tang Huanwen [0781 3562 2429] of the Department of Applied Mathematics, and Zhang Lidong [1728 4539 2639] of the Dalian Experimental High School: "Applications of Microcomputer in Newspaper Composing and Editing"]

[Text] I. Structure Design in Newspaper Composing and Rough Program Flow Diagram

1. Brief Introduction

In publishing newspapers, composing and editing work must be designed ahead of time. This type of work is very complex and requires a lot of time for repeated design and modification. In order to reduce the work load, beautify the layout and enable newspapers to report major events timely, we developed an automated newspaper layout design system to replace manpower by a microcomputer. In a real example, the color graphics functionality of the microcomputer was successfully applied to plot the desired layout pattern.

The so-called newspaper layout design (BZHB) involves the following: the total capacity of a certain edition of the newspaper S, the number of articles to edit n, the numbers of words in various articles B_1, B_2,...,B_n, and the type of each article (such as headline, picture and ordinary communication and commentary) are given in sequence. It is required to design a layout to satisfy that 1) the total capacity is S, 2) $B_1+B_2+...+B_n=S$, 3) each article is not allowed to cross its boundary, 4) the headline must be clearly displayed and its contents follow, 5) pictures and articles with fancy borders are not permitted to be next to each other, 6) the texts and graphics in articles with pictures and fancy borders must be clearly labelled, and 7) the "seating" number of each article must be written in the layout to allow the editor to examine and modify, as well as to allow the worker to typeset.

It is a meaningful task to let a microcomputer design an ideal layout to satisfy the above requirements. The entire design plan in the BZHB system introduced here has already been realized on an Apple II microcomputer using

advanced BASIC. Furthermore, it passed an actual application to design the front page of DALIAN RIBAO [DALIAN DAILY NEWS]. The results are shown in Figure 2 and the layout is shown in Figure 3.

2. Supporting Hardware

Apple II with monitor, Model X-YMP1000-21 plotter and Model PX-80 line printer.

3. Supporting Software

1) Apple II DOS 3.3 Disk Operating System, 2) Apple Soft BASIC interpreter and 3) Apple II MP 1000-Z1 plotting language.

4. User Application Program

1) ZZ01, the main composing and editing control program, controls six functional modular programs. 2) ZZ02, the main plotting control program, controls six plotting programs. 3) ZZ03 is the file initialization program. The main composing and editing control program, ZZ01, can be divided into five functional parts: the main control which includes the selection of functionality and installation of switches, data input and processing which includes modules for manuscript input and processing and data file accessing, retrieval which includes the cyclic retrieval module and the obstacle processing module, output, and plotting. These parts are linked according to Figure 1. Figure 2 is a rough flow diagram of the program.

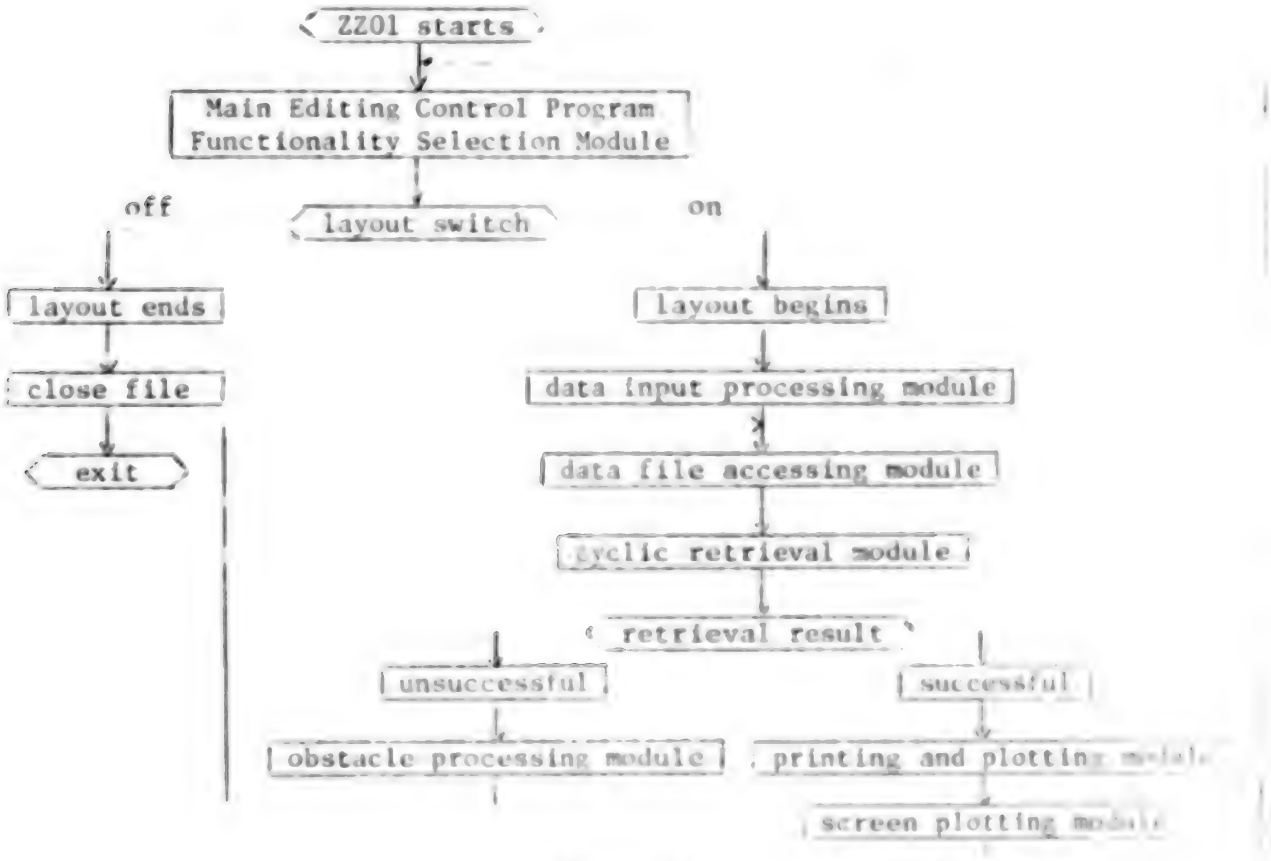

Figure 1

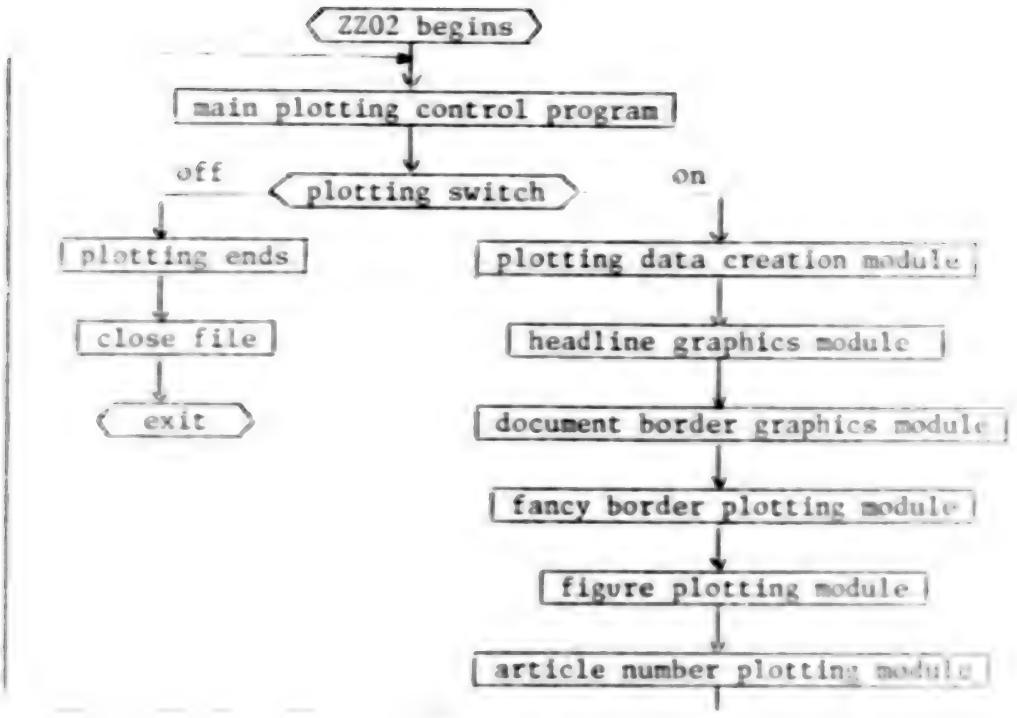

Figure 2

II. Program Design of BZHB

1. Description of the Method

In designing the automatic newspaper layout by microcomputer, we adopted a simulated manual layout method. The fast speed of the microcomputer and the abundant external storage resources are fully utilized. Data files for the total words in each edition and the total number of articles are established. Information in data files on external storage can be used in sequence to plot various ideal layouts. When a layout design is required, the initial data (number of articles) is used to compare the corresponding areas in the data file and the key retrieval sequence. Furthermore, a pair of multiple retrieval techniques are used to "seat" the data correspondingly. In the meantime, we finish manuscript sequencing and fancy border positioning to accomplish retrieval. If retrieval is unsuccessful, we can use the function to reduce or expand similar type of article automatically to eliminate the obstacle until the retrieval is successful.

2. Input and Processing of Initial Data

In order to make it easy for the end user and to save computer time, it is only necessary to enter the following data in running this program: 1) total number of words on page S, 2) total number of articles on the page n, and 3) number of words in each article B_1, B_2,...,B_n. In addition, we must enter them according to the sequence of headline, picture and general communication and commentary. (This arrangement not only facilitates the end user but also greatly simplifies the program design.) We also specified that an extra

label 1 must be added in front of the number of words B_1 of an article with fancy borders. For instance, 600 should be entered as 1600. (This arrangement frees the user from entering additional information for such articles.)

After considering the complexity of the problem and possible error in manual control, the program introduces various techniques to judge whether the data are rational. A manuscript data input processing module was compiled to determine whether the data satisfy the following relation:

$$S = \sum_{i=1}^{n} B_i$$

When this relation is not satisfied, the system prompts the user to modify and re-enter the data. The fancy border label 1 is treated by separation to take 1 or 0 and store in R(n) for the user to plot later.

3. Output of Results and Plotting

This part is directly supplied to the end user to ensure the integrity of the data and clarity of the format. The output includes two parts: 1) printing a table such as Table 2 and 2) plotting a sample page such as the one shown in Figure 3.

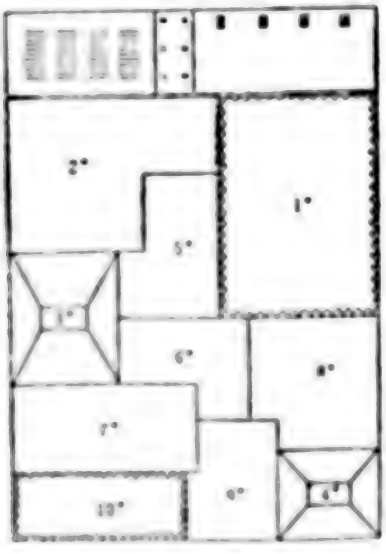

Figure 3

The plotting program was designed to use the VP1000-21 plotting language. Six plotting modules were designed to explore the pattern. Expressions are used as the plotting parameters in order to minimize the statements required to finish plotting the entire page including headlines, fancy borders, pictures, and serial numbers.

III. File Organization in BZHB

In order to meet different layout requirements, the program was designed with a data file technique. The file is serial and each record is composed of a 2(m+2) area (m is the number of vertices of the article in the layout). Table 1 shows the format of a record. The information stored is in integer form and the data structure is relatively simple. The data stored is compressed to a minimum to allow the storage of a great deal of information with limited external storage facility. In addition, the speed to process integers is also appreciable.

Table 1. Format of a Record

Name of information domain	Words in article	Number of vertices	Abscissa of vertex 1	Ordinate of vertex 1	.....
Content	B_1	m	x_0	y_0	.....

Name of information domain	Abscissa of vertex m	Ordinate of vertex m	Abscissa of center	Ordinate of center
Content	x_{m-1}	y_{m-1}	x_m	y_m

IV. Special Features of BZHB

1. It is only required to enter m+2 initial data points in running this system. The amount of data is small and they are simple. It is easy for the end user.

2. The program structure is simple and its running speed is fast. It may be used by daily newspapers which require page layouts on a day-to-day basis and becomes a powerful tool.

3. A data base containing various layout information is created by taking advantage of external storage facilities of the microcomputer. Consequently, the program is simplified to run faster.

4. As long as a sufficiently large data base is created to include an inventory of various layouts, the user may choose a desired Layout number. Or, he may use a portion of the program to plot the layout immediately, instead of entering m+2 data points to facilitate the user further and save time.

5. In addition to printing all the layout information, the program is capable of displaying color patterns on the monitor or plotting them on the plotter for direct viewing by the editor. If the layout is not satisfactory, modifications and changes can be done immediately.

V. An Example

In this example the layout design of the front page of DALIAN RIBAO is shown. The upper portion (one-sixth of the page) is the headline. The upper right remains fixed for important news with words ranging from 550-600. In addition to the headline, the page holds 10 more articles, n=10. The total words in the page is S=7000. The articles include two major news articles B_1=1060 and B_2=1540, two articles with pictures B_3=600 and B_4=420, and six ordinary communications and commentaries B_5=720, B_6=690, B_7=400, B_8=580, B_9=510 and B_{10}=480. (Titles and figures are converted into words.) Let B_2 and B_{10} be the ones with fancy borders. Therefore, B_2=11540 and B_{10}=1480. When S, n, B_1, B_2,...,B_{10} are entered, BZHB very quickly provides results as shown in Table 2 and layout as shown in Figure 3.

Table 2

SHU CHU JIE GUO,

No.	<I>	B(I)	<I*B>
#1	<2>	1540	<1>
#2	<1>	1060	<0>
#3	<3>	600	<0>
#4	<4>	420	<0>
#5	<5>	580	<0>
#6	<9>	510	<0>
#7	<6>	720	<0>
#8	<8>	690	<0>
#9	<7>	400	<0>
#10	<10>	480	<1>

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APPLIED SCIENCES

CZOCHRALSKI GROWTH OF TUNABLE LASER CRYSTAL $BeAl_2O_4:Cr^{3+}$

Beijing GUISUANYAN XUEBAO [JOURNAL OF THE CHINESE SILICATE SOCIETY] in Chinese
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[Article by Ma Xiaoshan [7456 4562 1472], Hou Yinchun [0186 0603 2504], Wang Siting [3769 0934 0080], Shen Yafang [3476 7161 5374], and Jin Zongru [6855 1350 0320]** all of Shanghai Institute of Optical and Fine Mechanics, Chinese Academy of Sciences*]

[Text] Abstract: Optically homogeneous alexandrite blanks, 100 mm in length and 20 mm in diameter, were grown by Czochralski technique using rf heating. These blanks were fabricated into 90 mm long 5 mm diameter c-axis laser rods. Tunable laser output was obtained experimentally. Spectroscopic characteristics of the crystal were presented. Problems such as prevention of BeO contamination, chrysoberyl formation kinetics and melt aging are also discussed.

I. Introduction

Chrysoberyl containing various impurities is a synthetic gem. Its growth and properties had been studied long ago [1]. Recently, chromium containing alexandrite was used as a tunable laser working substance and attracted much attention. This type of laser has a simple structure, high output power and wide tunable range. It can be operated at room temperature and the material has good physicochemical and mechanical properties [2]. Recently an alexandrite laser has been used in the annealing of ion implanted semiconductors. It was proven that silicon has a stronger absorption coefficient in this wavelength region ($\sim$ 750 nm). The result was better compared to that of the YAG:Nd^{3+} laser [3]. In military applications, enemy countermeasures will become ineffective when such laser is used in ranging and target designation because of its tunable output wavelength. It is apparent that this laser will be widely employed in many areas such as laser spectroscopy and frequency

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modulated optical communications. Therefore, this crystal growth process and its applications in laser are being studied in countries such as the United States, the USSR and Japan [4-7].

Alexandrite and olivine are isomorphous. The space group is $Pnma^{***}$. It belongs to the orthorhombic system. Each unit cell contains four molecules [3]. The cell constants are a_0 = 5.475Å, b_0 = 9.404Å and c_0 = 4.426Å. The oxygen atoms in chrysoberyl are in a distorted dense hexagonal pile. A beryllium atom is located in the body center of the oxygen tetrahedron, occupying 1/8 tetrahedral interstitial lattice. An aluminum atom is in the center of an oxygen octagon, occupying 1/2 of an octagonal interstitial lattice. Aluminum atoms have two lattices. Al_1 has a distorted center of symmetry and Al_2 is on a face symmetric lattice. The average Al_1-O bond is 1.890Å and the average Al_2-O bond is 1.938Å. Because of the bond distance, larger atomic radius species such as Cr or Fe have priority over Al_2.

II. Materials

Beryllium Oxide: Product of the Sixth Smelting Operation Plant of Baoshan Shuikoushan Mining Administration, >99.9 percent pure. The impurity contents are shown in Table 1.

Table 1 Impurities in BeO powder (ppm)

Si	Fe	Pb	Mg	Cr	Ni	Al	Cu	Mn	K
84	[illegible]	11	11	30	6	99	9.4	11	14
Ca	Sb	Co	Ag	Bi	Ti	Mo	Zn	Na	
66	<3	<3	<1.5	<3	<3	<3	<10	<8	

Aluminum oxide with ruby lumps was grown by a flame method. Its impurities are shown in Table 2.

Table 2 Impurities in ruby lumps (ppm)

Cr_2O_3	Na_2O	Fe_2O_3	CaO	MgO	CuO	MnO	PbO	ZnO	B$_2$O
[illegible]	<10	<20	<10	<20	<10	<10	<10	<10	?

Chromium oxide was chemically pure grade.

The binary phase diagram of Al_2O_3-BeO is shown in Figure 1. From Figure 1 one can see that $BeAl_2O_4$ is a congruent melt, therefore, they are combined stoichiometrically.

Because of the high toxicity of BeO powder, its content in air should not exceed 1 $\mu gBe/m^3$; otherwise, the operator might be poisoned. Special care caution should be taken in the entire crystal growth process to avoid poisoning due to BeO dust. BeO was weighed in a glove hub. Combined with other measures, the beryllium content in air could be maintained at less than 0.5 $\mu g/m^3$.

***In order to have a consistent discussion, a_0, b_0, and c_0 are determined in accord with ASTM 10-62, hence different from those in reference [3].

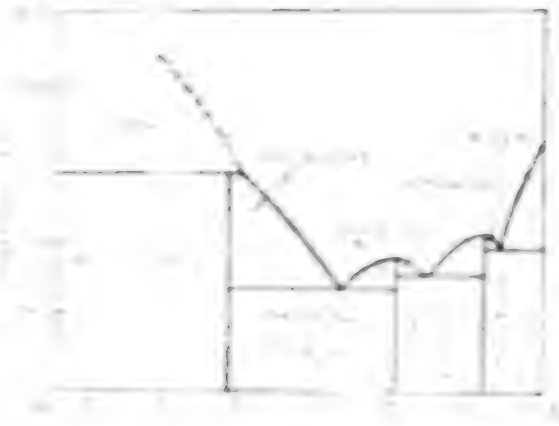

Fig. Phase diagram of BeO-Al$_2$O$_3$ system
after (reference)

BeO(s) and Cr$_2$O$_3$ were mixed in an alumina crucible and heated to 1150°C for 12 hours. The volume of BeO was contracted to a sintered block approximately half the original size. Because of the partial reaction between BeO and Al$_2$O$_3$, a small amount of BeO adhered to the wall of the crucible. However, the BeO inside was not affected. It was not necessary to remove the small amount of materials sticking to the wall either. Stoichiometric amounts of BeO (s), AlN (s) and chromium oxide powder were weighed and mixed in an agate mortar. We also attempted to fire an 8wt. % Al$_2$O$_3$ and 1wt. % Cr$_2$O$_3$ mixture compact at 1300°C for 4 hours. X-ray powder diffraction photographs showed that BeO already essentially went into solid solution. But, the volume of this mixture did not contract significantly even after heating at 1600°C for 24 hours. It was unfavorable to be used in our experiments. If this mixture is pressed, it will be more difficult to press a beryllium powder into pellets. The BeO powder and rods used in our work as substrates for silicon were purchased from Brush Wellman Inc. Their purity was 99.5%. Their impurities were mainly Al$_2$O$_3$ (0.3%), SiO$_2$ (0.1%), Fe$_2$O$_3$ (0.05%), and MgO (0.05%). These impurities did not affect the electrical properties of BeO crystals, but they caused BeO contamination. Actually, single crystal BeO(Al$_{2x}$Cr^{3+}$_x$)O crystals could be obtained by using high purity BeO, Al$_2$O$_3$, and Cr$_2$O$_3$ powders.

Growth of Epitaxial Layers

Vapor phase epitaxial growth was applied to grow GaN epitaxial layers on the BeO substrates, based on the work of Maruska et al. [8]. Gallium metal at 1000°C was used as the source material. BeO and Al$_2$O$_3$ powder could be easily contained in the gallium melt. However, the experiments lasted for 1-2 hours were carried out using the pulling method to initialize the growth of crystal on the substrate. The specific time is determined by the temperature and the flow rate of the gases. Nitrogen gas was usually passed over the surface of the gallium melt. Mixtures of the gases were used in the experiments. Nitrogen and argon gas were used to dilute the ammonia gas. Hydrogen gas was usually passed over the surface of the gallium melt. The temperature was raised gradually to melt the gallium. It was observed that the fluidity of the melt was poor. Because of the low growth rate, the liquid melt was not consumed. This phenomenon will obviously affect crystal growth.

The power mV_P and crucible bottom temperature mV_T were simultaneously recorded in the experiment; both were in relative values. The numerical values varied with changing experimental conditions. A typical situation is shown in Figure 2. Curve 1 is the variation of mV_P with time, manual or automatic control. At point A, the power was increased manually. Curve 2 shows the mV_T vs time curve. From this figure one can see that mV_T could rapidly respond to changes in mV_P with a slight lag. At one particular moment, 6 hours after the raw materials were melted, mV_T suddenly dropped as shown in Figure 2B. This phenomenon is called the temperature flip-flop effect. It could be considered that the melt was not thoroughly mixed before this time and the top portion was rich in Al_2O_3. After thorough mixing, the radiation transmittance of the melt increased drastically, leading to a huge decrease in temperature at the bottom of the crucible as shown at point B in Figure 2. It was proven that the crystal grown before the temperature flip-flop was not transparent. Only new crystal grown under this non-transparent crystal after the temperature flip-flop is transparent*.

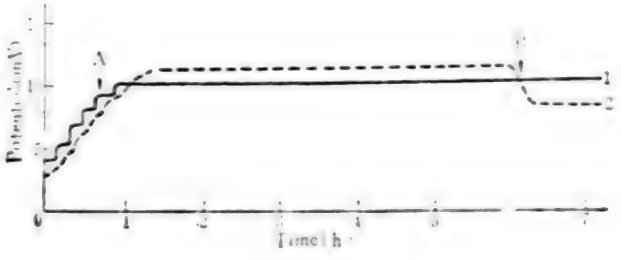

Fig.2 Curves obtained by XWT-264 recorder for input power and temperature at the bottom of the crucible respectively 1—mV value from pickup coil (mV_P) ; 2—mV value from silicon photocell (mV_T)

The temperature at the bottom of the crucible could also be affected by melt convection. It was demonstrated experimentally that the presence of temperature flip-flop is only related to the mixing condition of raw materials and the geometry. The temperature rising rate and melting temperature could only affect the timing of the flip-flop, not whether it occurs. Furthermore, temperature flip-flop has not been observed after a melt is cooled down and then heated up again. These facts are inconsistent with the temperature drop corresponding to convection. We believe that the melt is homogeneous when the temperature flip-flop takes place. The reaction is complete and the radiation transmittance is increased to reduce greatly the temperature at the bottom of the crucible. Because it is homogeneous the crystal obtained is transparent.

IV. Melt Aging

As described above, it is easier to obtain transparent single crystal alexandrite if the seed is planted in time immediately after the flip-flop.

*Color crystal photo is omitted.

Satisfactory results cannot be obtained if seeded ahead of time. If the temperature is not well adjusted to grow crystal in time after the flip-flop, experiments will also fail. In this case, white or semi-transparent crystals may be obtained. The crystal grown at high temperatures appears to be especially transparent and bright. Sometimes, crystal edges and crystal planes may be present. However, after the crystal is grown to a certain length, the top of the crystal becomes opaque and its surface flakes off. Finally, it breaks off. This effect occurs more frequently when left over materials are used in the crystal growth process. Another interesting thing is that when a transparent crystal falls into the melt by accident and is remelted, the new crystal grown is an opaque material.

R.C. Linares [11] found that transparent alexandrite could not be obtained using an aged melt. It was described as a "melt aging" effect. We generalized phenomena to melt aging. X-ray diffraction analysis of the transparent and opaque crystals showed no significant difference between their diffraction peaks. The differences were found in a few weak peaks and some slight shifts in the diffraction pattern. These discrepancies are being further studied.

We have the following hypothesis with regard to melt aging: A high temperature melt is not totally beryllium aluminate. It is possible to have some Al_2O_3 or BeO and $3BeO \cdot Al_2O_3$ or $BeO \cdot 3Al_2O_3$ present. The aluminum rich constituent has a higher density and the beryllium rich constituent has a lower density. Gravity causes the aluminum rich constituent to sink. In our experiment, the geometric arrangement of the raw materials in the crucible was that the BeO sinter was on the bottom and ruby lumps on top. Therefore, a transparent $BeAl_2O_4:Cr^{3+}$ crystal might be grown if seeded at the proper time (i.e., $BeO:Al_2O_3 \approx 1:1$ near the surface of the melt). When the surface is aluminum rich, the crystal becomes opaque. However, as BeO floats upward, the composition becomes just right for the growth of a transparent crystal on the opaque crystal. But if BeO continues to float upward to form a beryllium rich surface, there is no way for the transparent crystal to continue growing. In order to confirm this hypothesis, we added approximately 1 g of alumina powder to the beryllium rich surface of an aged melt (i.e., a used cold melt not capable of producing transparent crystals). It was verified experimentally that this method could overcome melt aging and produce transparent crystals under certain conditions. Based on this hypothesis, transparent crystals could not be grown if the geometric arrangement in the crucible is altered, i.e., BeO sinters are placed on top of ruby lumps. This was also experimentally verified.

V. Crystal Growth and Testing

1. Crystal Growth

The furnace and its associated apparatus are about the same as reported in previous work [12]. Iridium crucibles and high frequency induction heating are used. Amorphous zirconia was used as a thermal insulator. The protective atmosphere was argon. 2 mm diameter iridium wire was used to pull the crystal out for the first time. Large size single crystals were selected

from the polycrystalline block and cut into a-axis crystal seeds in order to grow a-axis crystals. From these crystals b-axis crystal seeds were obtained. Finally, c-axis crystal seeds were obtained by cutting from b-axis crystals. Laser rods were all cut from crystals grown along the c-axis. The maximum crystal size is 20 mm in diameter and 100 mm in length. It could be processed into 5 mm diameter, 91 mm long and 4 mm diameter, 96 mm long laser rods. The crystal could be cut without annealing. We did not observe any cracking. It indicates that there was no high stress in the crystal.

2. Crystal Growth Morphology

The growth rate of alexandrite is apparently anisotropic. It is fastest along the <100> direction and slowest along the <001> direction. Therefore, crystals grown along the a-axis and b-axis are often in the shape of slices. The width to thickness ratio could reach 4:1. Crystals grown along the c-axis may have many shapes, such as a thick plate, elliptical rod or hexagonal rod. The shape is related to the temperature field and growth parameters. Figure 3 shows some frequently seen crystal cross-sections. These cross-sections are similar to those described in the literature [6]. However, the Miller indices in the literature are different from our results. A small 2 mm diameter c-axis rod was cut perpendicular to the <001> face of a b-axis crystal. Its lattice constant was found to be 4.44Å using a revolving x-ray camera, in agreement with the literature value. Two optical techniques were also used in this verification. In addition, the PBC theory used to prove the calculated values was consistent with the experimental ones [15].

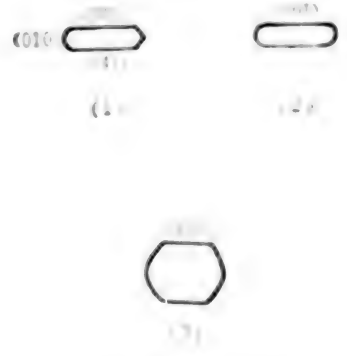

Fig.3 Cross section of alexandrite crystals

(1) —a-axis crystal, (2) —b axis crystal, (3) —c-axis crystal

3. Crystal Spectroscopy and Laser Experimentation

The fluorescent and absorption spectra of $BeAl_2O_4:Cr^{3+}$ are shown in Figures 4 and 5, respectively. The crystal energy levels of $BeAl_2O_4:Cr^{3+}$ were also calculated from the absorption spectra. The V band of Cr^{3+} was also determined using unpolarized light, as shown in Figure 6. From Figure 4 one sees that the fluorescent intensity in the 750-850 nm range increases with increasing temperature between 50-300°C. Consequently, the lasing property may improve with rising temperature.

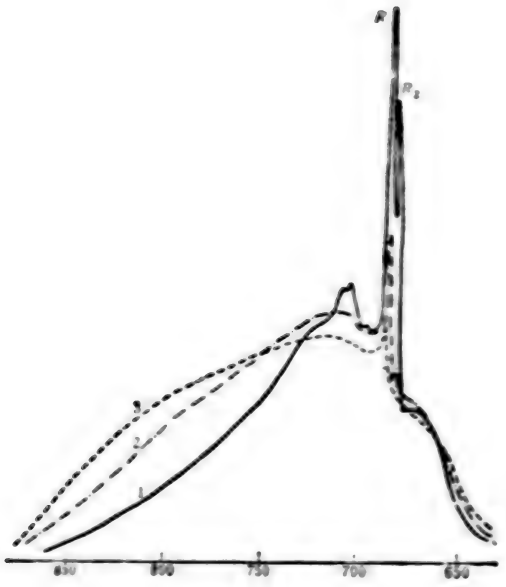

Fig.4 Fluorescent spectra of alexandrite
($E \parallel a$)
1——50℃, 2——200℃, 3——300℃

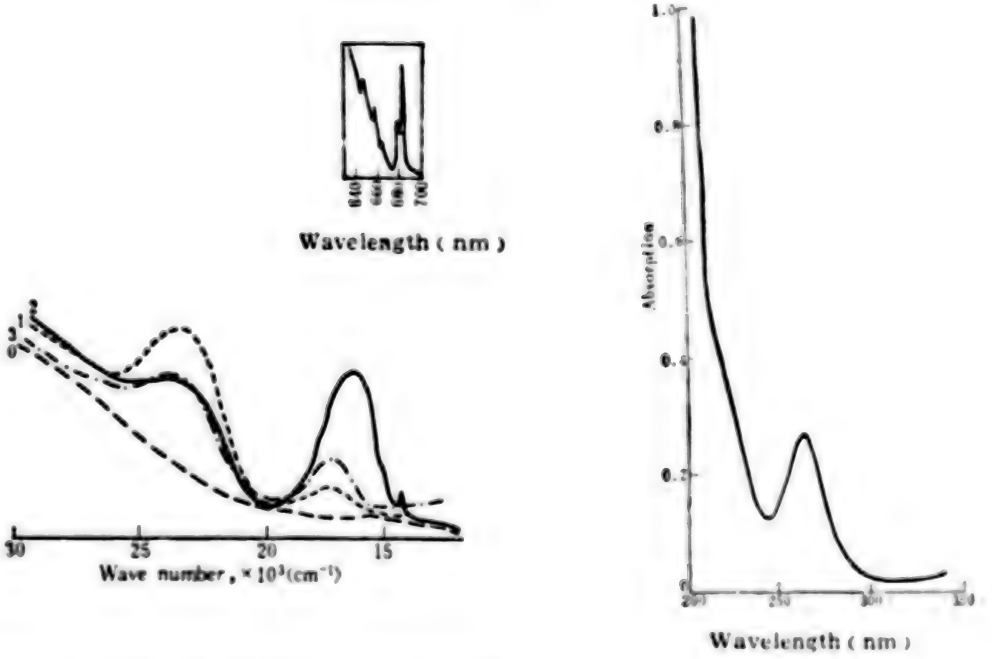

Fig.5 Absorption spectra of alexandrite at 25°C
Figure on the upper-right is a part of the high resolution spectrum
1——$E \parallel a$, 2——$E \parallel b$, 3——$E \parallel c$, 0——Base line

Fig.6 Near ultraviolet absorption band (V band) of alexandrite (without polarizer)

Currently, the $BeAl_2O_4:Cr^{3+}$ laser rod could already lase at 7526Å due to electronic-vibrational transition. The threshold is approximately 90J. Coherent output has already been obtained. Furthermore, the laser output efficiency indeed improved with increasing temperature.

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CSO: 4008/42

APPLIED SCIENCES

ALUMINUM-GRAPHITE COMPOSITE MATERIALS STUDIED

Dalian DALIAN GONGXUEYUAN XUEBAO [JOURNAL OF DALIAN INSTITUTE OF TECHNOLOGY] in Chinese Vol 24 No 3, Sep 85 pp 109-112

[Article by Liang Lida [2733 4539 6671] of the Casting and Research Section of DIT: "An Investigation on the Properties of Cast Aluminum-Graphite Composite Materials"*]

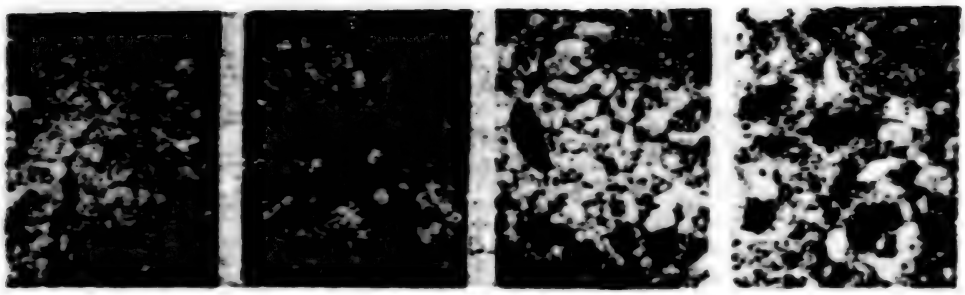
[Text] Abstract: In this work the wear reduction, damping capacity and technical properties of rheocast aluminum-graphite composite materials were tested. The effect of graphite content on various properties was determined to serve as a technical basis for this type of materials.

1. Preparation of Cast Aluminum-Graphite Materials

Al-9%Si-3%Cu-1%Mg was chosen as the matrix of the cast aluminum-graphite material. The particle distribution of the graphite is as follows: 70 mesh 25.5 percent, 100 mesh 12 percent, 120 mesh 26.6 percent, 160 mesh 19.6 percent and >160 mesh 16.6 percent. The aluminum alloy is pre-cast into an ingot and then melted in a ceramic crucible. When the alloy becomes semi-solid (40-60 percent of the alloy is solid), a blending blade pre-heated to approximately 600°C is inserted to stir the alloy. Graphite particles are added while stirring until they are uniformly distributed in the semi-solid aluminum. The fluid is then die cast into the desired shape. This method is called the rheocast method. Graphite particles free of copper and nickel can be used in this method. The technique is simple and easy. Graphite is evenly distributed. The graphite content may be very high. The quality of the aluminum-graphite material is very high, just as in other rheocast processes.

The metallographic structures of aluminum-graphite materials containing various amounts of graphite are shown in Figure 1. In the photograph, we cannot see the nascent α phase tree structure. This type of structure is crushed in the rheological process. The aluminum matrix is composed of nascent α phase and eutectic structure. Graphite particles are mostly in eutectics. A very small amount is in the α phase.

*Manuscript received on 19 October 1984.
Liu Fuyi [0491 4395 5030] also participated in the experimental work.

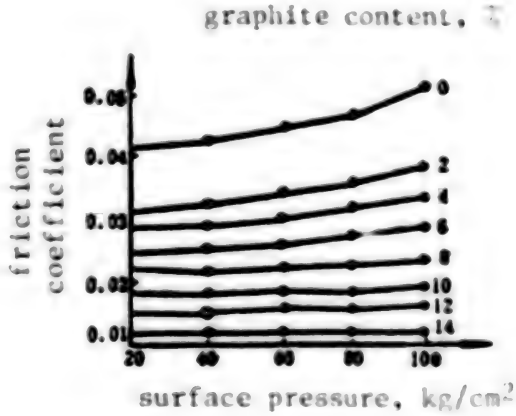


0% graphite 4% graphite 8% graphite 12% graphite

Figure 1. Metallographs of Aluminum-Graphite Materials 100X

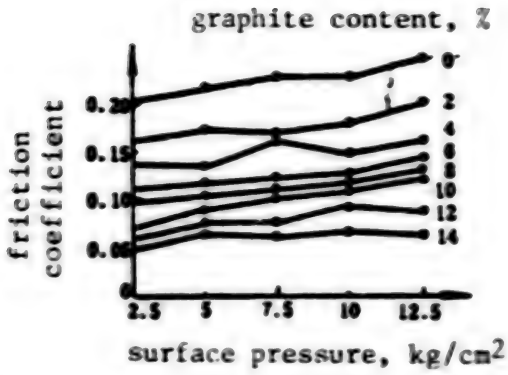
2. Wear Reduction Property of the Material

Materials with various graphite contents were fabricated into friction specimens in order to determine the relation between friction coefficient and pressure under oil lubricated and dry conditions on a frictional wear machine. The results are shown in Figures 2 and 3. The results indicate that the addition of fine graphite particles could lower the friction coefficient in both dry and wet conditions. With increasing graphite content, the magnitude of the drop of friction coefficient also increases.



lubricating condition: oil; rotational speed: 400 r/min; grinding material: steel

Figure 2. Surface Pressure vs. Friction Coefficient



lubricating condition: dry; rotational speed: 200 r/min;
grinding material: steel

Figure 3. Surface Pressure vs. Friction Coefficient

Based on friction theory we know that a solid lubricant graphite has the following special characteristics:

1. The shear strength of graphite is lower than that of the grinding surface material.

2. Graphite itself has certain adhesion to aluminum and steel.

3. Graphite has an isotropic crystal structure; high compressive strength and low shear strength.

4. The above characteristics do not change significantly with the environment.

Graphite forms a thin lubricating layer between the axle and the bearing. Graphite particles are uniformly distributed in the aluminum alloy matrix. No matter how the worn surface is re-generated, there are always graphite particles on the surface with a self-lubricating effect. The higher the graphite content is, the better the self-lubricating effect becomes and the larger the friction coefficient drops.

3. Damping Capacity of the Material

Various graphite content materials were used to fabricate 1.0 x 10 x 80 mm damping samples. Resistance foil gages were adhered to both sides of the specimen. The strain signal is sent to a dynamic strain meter. It is then amplified and sent into an oscilloscope. One end of the specimen is secured. An activator at a fixed vibration frequency is applied to the cantilever end. After the applied energy is removed, the specimen begins damping. The damping wave is recorded on the oscilloscope to evaluate the damping characteristic of the material by exponential decay. The equation is:

$$Q = \ln(q_k/q_{k+n})/n$$

where Q--natural logarithmic decay rate; n--number of vibration peaks measured; q_k--amplitude of the k^{th} vibration wave; and q_{k+n}--amplitude of the $k+n^{th}$ wave. The natural logarithmic decay rates of materials with various graphite contents are shown in Table 1.

Table 1

Graphite content, %	0	2	4	6	8	10	12	14
Decay rate Q	0.019	0.025	0.030	0.036	0.041	0.045	0.049	0.053

The results show that the higher the graphite content the better the damping characteristics of the material.

Cast iron is a familiar damping material in which graphite is distributed in the steel matrix. The aluminum-graphite material, however, has graphite dispersed in an aluminum matrix. The structures are very similar and their properties must also be similar. The decay rate of cast iron is higher than that of aluminum. The ratio of the decay rate of aluminum-graphite to its density is much larger than that of cast iron. This means that for the same weight, an aluminum-graphite material can absorb more vibrational energy than cast iron. Aluminum-graphite materials can be used to make various damping components in the aeronautic industry and in noise reduction.

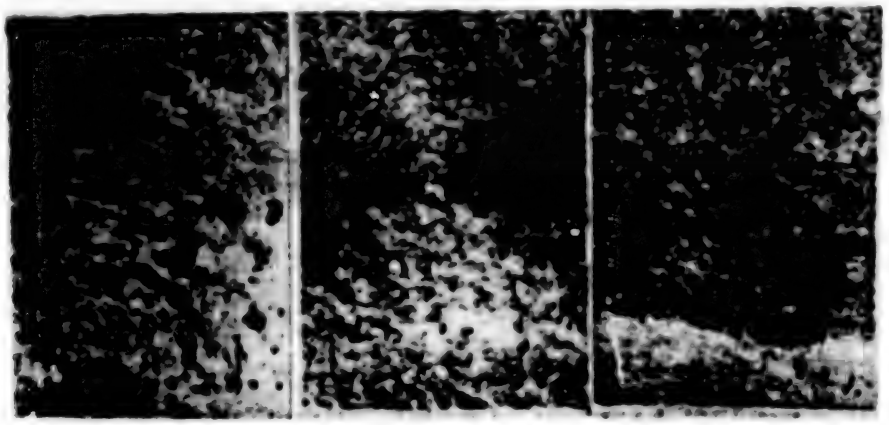
4. Remelting of Aluminum-Graphite Materials

An aluminum-graphite material containing 12 percent graphite was placed in a crucible and heated in an electrical furnace. The remelting temperatures are 580°C, 720°C, and 800°C. The temperature was maintained for 30 minutes. Figure 5 shows the longitudinal cross-section of the macro-structure of remelted samples.

The results indicate that the distribution of graphite particles was changed. When the remelting temperature is relatively low, graphite particles are concentrated. However, floating is not serious (see Figure 4.a). When the temperature is too high, the graphite is not concentrated. It, however, generally floats up. The lower part of the sample has a graphite free region (see Figure 4.c). In the region with graphite, it is uniformly dispersed. At 720°C, the graphite behavior is between those at high and low temperatures (see Figure 4.b).

The phenomenon discussed above can be explained as follows: when the remelting temperature is relatively low, thermal convection in liquid aluminum enhances the probability of contact between graphite particles. The surface tension of graphite and that of liquid aluminum are very high. The aggregation of particles in contact can reduce the surface energy, which lowers the total energy of the system. It is very difficult to separate these particles once they become an aggregate. This aggregation, however, is not unlimited. Instead, it is localized. This is how graphite aggregates are created. This effect is related to the weak convection current in liquid aluminum at low temperatures. In this situation, the viscosity of liquid aluminum is very

large and the tendency for graphite particles to float upward is very small. Therefore, we did not see a graphite free zone on the bottom of the specimen. When the temperature reaches 800°C, the surface tension of graphite and that of liquid aluminum decrease. The aggregation of several graphite particles cannot significantly lower the free energy of the system. In addition, the vigorous thermal convection of liquid aluminum will separate those graphite particles already aggregated. The viscosity of high temperature liquid aluminum is relatively low, resulting in the floating of graphite. Thus, there is a graphite free area in the lower portion of the sample. The upward floating velocity of a graphite particle obeys Stoke's equation which is related to the dynamic viscosity coefficient of liquid aluminum. With increasing temperature, this coefficient decreases and the upward velocity increases resulting in an increase of upward distance within a fixed time period.



a. 580°C b. 720°C c. 800°C

Figure 4. Effect of Remelting Temperature on Graphite Particle Distribution

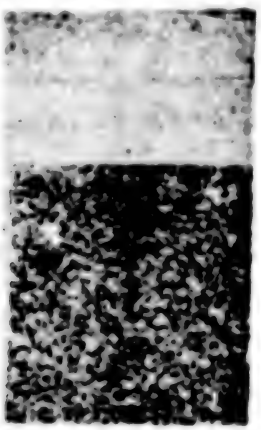


Figure 5. Aluminum-Graphite Containing 35 Percent Graphite X2

Aluminum graphite composite materials with higher graphite contents can be obtained by taking advantage of the phenomenon that graphite particles do not aggregate during remelting at high temperatures. Although they float upward, however, they do not precipitate out of liquid aluminum. A technique was used to remelt an aluminum-graphite material at 820-840°C for 15-20 minutes and then to concentrate them by removing the graphite free part on the bottom of the crucible, resulting in a material containing a graphite content of as high as 35 percent. The macroscopic cross-section of this material is shown in Figure 5.

5. Thioxcast of Aluminum-Graphite Materials

A rheocast aluminum-graphite ingot was heated in an electric furnace. The temperature rising curve of the specimen is shown in Figure 6. The solid phase content at point B was determined to be 35 percent by liquid quench and quantitative metallographic analysis. As the temperature of the specimen rose to point A, the eutectic began to melt. At point B the eutectic component was completely melted and the solid phase was 35 percent. The ingot was cast in a die cast machine. The result showed that the material could form well. An observation of the sample structure revealed that the graphite was dispersed even more uniformly. It is feasible for a plant to use rheocast ingots for die casting to facilitate automated production.

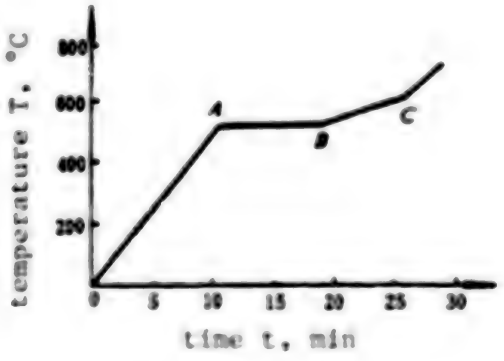


Figure 6. Sample Temperature Rising Curve

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ENVIRONMENTAL QUALITY

WATER RESEARCH HELPS CUT ANTIPOLLUTION COSTS

WO241330 Beijing XINHUA in English 1318 GMT 24 Jan 86

[Text] Beijing, 24 Jan (XINHUA)--Chinese scientists have conducted a survey of the pollutant-assimilating capacity of three rivers, thereby saving for the state 200 million yuan of pollution-control investment.

By analyzing the water of the 200 km section of the Tuojiang River that runs through Sichuan Province, scientists found that the section has the assimilating capacity of 90 tons of organic pollutants every day.

They said that to control the pollution in the river, investment should mainly focus on a chemical plant on the upper reaches of the river and dispose of more than 3,600 tons of the pollutants discharged daily by the plant.

Their results and proposal were accepted by the local government, saving the Province 92 million yuan in investment for pollution control along the river.

After studying an area of over 100 sq km of the Shenzhen River and nearby bay in Guangdong Province, the scientists put forward a suggestion that sewage from Shenzhen city should be discharged to the sea via the Pearl River mouth, reducing the cost of disposal by some 100 million yuan compared to the city's original plan to build 10 sewage treatment plants.

The survey of the section of the Xiangjiang River near Zhuzhou city in Hunan province showed that heavy metal sediment in the river is chemically stable, and the only measure to keep the water quality in line with the standards set by the state is to treat the sewage from the Zhuzhou smelter and other industrial plants.

Water assimilating capacity research, listed as one of the country's major scientific research projects for the sixth five-year plan period (1981-1985), was conducted nationwide by 49 environmental protection units, including the Chinese Academy of Environmental Sciences.

China started research on water assimilating capacity in 1974 and has so far surveyed a dozen rivers. The State Science and Technology Commission has decided to conduct such research into the Pearl River Delta and lakes in the next five years.

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CSO: 4010/1028

ENVIRONMENTAL QUALITY

SHENYANG CITY INTRODUCES SMOKELESS ZONE

OW171154 Beijing XINHUA in English 1145 GMT 17 Jan 86

[Text] Shenyang, 17 Jan (XINHUA)--Fitting industrial boilers with filtering devices and installing domestic central heating systems have proved to be effective steps in eliminating pollution in Shenyang, a major industrial city in northeast China.

The city's 1.5 km Xinghua Street was notorious for the pall of black smoke which used to envelop it all day as a result of the concentration of boilers and coal-burning stoves.

But last year, 86 boilers were fitted with filters and the families in the street now all have central heating.

According to a provincial government official, Liaoning earmarked 760 million yuan for 3,100 environmental protection projects during the sixth 5-Year Plan (1981-1985). Some 3,278 have already been completed.

Facilities that can threat over 28.3 billion liters of waste water and 50.3 billion standard cubic meters of waste gas a year were built during the plan period.

The official said 11,490 of the province's 29,800 industrial boilers have been fitted with anti-pollution devices.

Last year central heating facilities which are able to provide heat for more than 34,000 square meters of apartments were installed in the city's busy Zhongjie Street, and smoke pollution has been virtually eliminated there.

The provincial environmental protection department said that in the past year Liaoning has set up 20 smokeless zones in other cities such as Dalian, Fushun, Benxi and Liaoyang.

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CSO: 4010/1028

ENVIRONMENTAL QUALITY

TIANJIN ENVIRONMENTAL PROTECTION MAKING HEADWAY

OW031557 Beijing XINHUA in English 1439 GMT 3 Jan 86

[Text] Tianjin, 3 Jan (XINHUA)--Chimneys in a Tianjin electric power plant have stopped emitting black smoke, indicating a major success of this north China industrial center in its effort to control air pollution.

The plant, now being rebuilt into a heat and power plant, used to be one of the city's three major air pollution sources.

Air pollution by other two, a carbon black factory and a steel mill, has also been brought under control, city officials said.

Tianjin spent 264 million yuan on environmental protection during the sixth five year period ending last year, and has so far completed 2,000 projects for that purpose.

While retooling factories to reduce pollution, the city government moved 108 pollution-causing factories out of the city center.

In addition, 300 electroplating workshops were closed down or merged into other factories.

A sewage treatment plant built during the sixth five-year plan period is able to treat one fourth of the city's sewage, thus reducing pollution of the Bohai Sea.

Tianjin residents planted 14 million trees and the green area increased by nearly one million square meters.

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ENVIRONMENTAL QUALITY

TIANJIN ESCALATES CAMPAIGN AGAINST AIR POLLUTION

OW181736 Beijing XINHUA in English 1508 GMT 18 Jan 86

[Text] Tianjin, 18 Jan (XINHUA)--Ninety-seven percent of industrial Tianjin's one million families will be cooking with gas by late next year as this coastal city escalates its campaign against air pollution.

Municipal officials said today only 26 percent of the city's families have gas cooking facilities, while the rest use coal stoves.

Wherever possible, they said, the city will help residents buy gas burners fueled by tanks or metered lines.

In addition, the city has begun building a system of centralized heating plants to eliminate coal-fired boilers in factories and heating stoves in residential buildings, according to the officials.

Trees will be planted to help clean the air and separate polluting industrial districts from the neighborhoods where most Tianjin residents live, they said.

The city campaign follows a survey of city pollution conducted by 300 scientists with the help of 7,000 residents.

They said the causes of Tianjin's air pollution must be attacked or, as one put it, "the smog by the end of the century will be as bad as London's at its worst."

The scientists found air problems stemming from burning coal, sandstorms, dirt, building materials and motor vehicle exhaust.

To keep the air clean, they said, the city must radically reduce coal use, isolate industrial areas with greenbelts and improve roads--both to cover dirt streets and to cut vehicle exhaust by improving traffic flow.

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ENVIRONMENTAL QUALITY

BRIEFS

XINJIANG ENVIRONMENTAL PROTECTION--During the Sixth 5-year plan period, the region's environmental protection cause developed rapidly. During the period, the region improved environmental pollution in regard to more than 1,800 cases and the total investment in this respect amounted to nearly 80 million yuan. The region has set up 51 installations for the disposal of waste water. Karamay City has invested some 3 billion yuan to build a waste water disposal plant. Some 40,000 vehicle in Urumqi City have been installed with low-volume loudspeakers instead of high-volume ones. Over the past 5 years, the region has built 16 natural environment protection areas, covering an area of some 84,000 square kilometers and accounting for 50 percent of the country's total natural environment protection areas. During the period the region made scientific research achievements in regard to 28 items of environmental protection. [Summary] [Urumqi Xinjiang Regional Service in Mandarin 1300 GMT 15 Jan 86 HK] /9738

FUJIAN ENVIRONMENTAL PROTECTION--Fujian achieved much progress in environmental protection work during the sixth 5-year plan period. Some 600 environmental protection projects were completed throughout the province during the period. Some 630 environmental workers are now working at various levels of environmental administration bureaus in the Province. Starting from scratch, the Province now has 9 plans specializing in manufacturing environmental protection equipment. Six provincial-level nature preserve parks and 2 agriculture preserves were set up in the past 5 years with a total acreage of 1.3 million mu. A total of 1.89 million mu of land was afforested. [Summary] [Fuzhou Fujian Provincial Service in Mandarin 1130 GMT 8 Jan 86 OW] /9738

CSO: 4008/1036

Analytical Chemistry

MASS SPECTRA OF SOME TRIMETHYLSILVYL DERIVATIVES OF PHOSPHONIC AND PHOSPHONOTHIOIC COMPOUNDS

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 35 pp 481-484

[English abstract of article by Guo Hangzhou [6753 2635 1558] and Cao Jinhong [2580 6855 7703] of the Academy of Military Medical Science]

[Text] Phosphonic and phosphonothioic acids are hydrolytic products of organophosphorus pesticides. The analysis of phosphonic and phosphonothioic acids is very important in environmental pollution control. Due to the presence of hydrogen bonds they are difficult to volatilize and, therefore, are not suitable for GC-analysis. In this paper a reliable method for derivatization of these compounds is introduced and the mass spectral fragmentation of these derivatives is discussed. (Paper received 4 May 1984.)

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1.5-DERIVATIVE POLAROGRAPHY BASED ON MICROCOMPUTER

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 484-488

[English abstract of article by Wu Shouguo [0702 1345 0948], Pu Guogang [5543 0948 0474] and Wang Erkang [3076 1422 1660] of the Department of Applied Chemistry, University of Science and Technology of China, Hefei]

[Text] A real-time controlled high-accuracy data acquisition and processing system is described and evaluated. The system is applied to acquire and process the linear sweep voltammetric data of a two-component system with HMDE. The original data is processed first with the 9-point least-square smoothing technique, then with a convolution transform algorithm to obtain semi-integral, semi- and 1.5-derivative polarograms. This neopolarographic method based on a microcomputer is much better at reducing noise interference than that using an electronic analog instrument and can improve the sensitivity and resolution of the analytical method. (Paper received 14 May 1984.)

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MODIFIED SIMPLEX OPTIMIZATION OF Ar-H_2 PLASMA EMISSION SPECTROSCOPY

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 498-503

[English abstract of article by Xu Liqiang [1776 4539 1730] of Shanghai Institute of Metallurgy, Chinese Academy of Sciences; and P. Schramel of the Institute of Applied Physics, Center for Radiation and Environmental Research, FRG]

[Text] This paper describes a method using partial factorial design (orthogonal test) and modified simplex optimization to optimize the operating parameters of an Ar-H_2 plasma, including observation height, power, flow rates of carrier Ar+H_2, auxiliary Ar+H_2, coolant Ar+H_2, to obtain maximum signal-to-background ratio. The block diagram of the microcomputer calculation is presented. The operating parameters for 14 elements are investigated by simultaneous ICP-AES and grouped according to the behaviors in such plasma. The detection limits of Cd, Fe, Cr, Be, Ni and V have been improved under the optimal operating parameters for Ca, which were recommended as compromise operating parameters for multielement analysis. (Paper received 18 June 1984.)

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STUDY OF THE EFFECT OF MIXED [illegible] SURFACTANTS ON COLOR REACTION AND ITS APPLICATION. II. THE [illegible] OF REACTION MICROENVIRONMENT ON SYNERGIC SENSITIZING EFFECT

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 569-571

[English abstract of article by Ni Jinren [2058 2429 1755] and Zhu Lizhong [2612 0448 0022] of the Department of Chemistry, Hangzhou University]

[Text] The formation of mixed micelle has been considered to be a main cause of the synergic sensitizing effect of mixed ionic-nonionic surfactants on color reactions. The effect of a surfactant mixture of CTMAB-Peregal O on both Cd-PAR and Al-CAS has been investigated in detail. The formation of mixed micelle has been further proved by surface tensions of the color systems. It may change such aspects of the microenvironment as the dielectric constant, electrical conductivity and the surface activity of color reaction systems. Moreover, some characteristics of color reactions, such as a change in the color reagent pK_a and the [illegible] of higher ligand complexes, may be influences by the mixed surfactants. (Paper received 1 September 1984.)

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CHEMILUMINESCENCE IN ENVIRONMENTAL ANALYSIS. II. DETERMINATION OF MANGANESE(II) IN MINERAL AND POLLUTED WATERS

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 510-514

[English abstract of article by Zheng Zhuzi [6774 2612 2737] and Wang Zunben [3769 1415 2609] of Xiamen University Chemistry Department]

[Text] Based on the catalytic action of trace manganese (II) on the oxidation of luminol in an alkaline medium, a chemiluminous method for the determination of manganese (II) in mineral and polluted waters has been developed with a luminous analyzer designed by the author. During the progress of the reaction, a light of definite wavelength is emitted, and its intensity is in proportion to the content of the manganese (II). This method is simple and quick. Its sensitivity is high and the detection limit is less than 1.0 ppb. The linear range is obtained from 1 x 10^{-9} to 5 x 10^{-6} g/ml and the reproducibility is good. The analytical results are satisfactory. (Paper received 2 September 1984.)

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CHRAMOTOGRAPHIC ANALYSIS OF HEAVY WATER VIA IRON POWDER CONVERSION METHOD

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 521-523

[English abstract of article by Li Shutang [2621 2885 1016] of Plant No 4400, Xianyang]

[Text] In this method the iron powder should be activated before use. During the analysis the water sample will react with activated iron at 700°C to produce H_2, then the deuterium content in the resultant H_2 is measured by chromatography to obtain the D_2O concentration in the water sample. This method is characterized by safety, simplicity, less trouble, low cost of analysis and it is harmless to the operators. (Paper received 14 March 1984.)

DETERMINATION OF TUNGSTEN, MANGANESE, IRON AND NIOBIUM IN PURE TUNGSTEN MINERAL AND TUNGSTEN ORES USING X-RAY FLUORESCENCE SPECTROMETRY

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 542-544

[English abstract of article by Chen Pitong [7115 0C12 6639] of Tianjin Institute of Geology, Ministry of Metallurgical Industry]

[Text] The sample is fused with lithium tetraborate and lithium bromide at 1050-1100°C in a platinum/5 percent gold crucible. Barium nitrate is added to the fusion mixture to act as a heavy absorber and an oxidizing atmosphere is maintained in the crucible during the early stage of fusion. Tantalum pentaoxide is added to the fusion mixture as an internal standard of tungsten. The accuracy and precision of the method are as good as those of the classical chemical method. (Paper received 18 May 1984.)

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A SIMPLE SINGLE CHANNEL FLOW INJECTION SPECTROPHOTOMETER

Changchun FENXI HUAXUE [ANALYTICAL CHEMISTRY] in Chinese Vol 13 No 7, 20 Jul 85 pp 545-548

[English abstract of article by Lu Yinzhong [0712 6892 1813] and Zhu Yongxuan [2612 0737 3551], et al., of the Institute of Geochemistry, Chinese Academy of Sciences, Guiyang]

[Text] A simple single channel flow injection spectrophotometer, consisting of a Mariot container (as the reagent reservoir and carry flow propeller), rotary sampling valve, PVC thin tube and micro flow through cell, has been developed. Its performance can meet the requirements of simple flow injection analysis. It has been applied to the determination of titanium and iron in standard rock samples. The results obtained are in agreement with the recommended values. The relative standard deviation of the determination is less than 4 percent. (Paper received 28 June 1984.)

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SELF-CALIBRATION METHODS OF SIX-PO[illegible]

Beijing DIANZI XUEBAO [ACTA ELECTRONICA [illegible]
Sep 85 pp 8-12

[English abstract of article by [illegible]
Institute of Radio Engineering, [illegible]

[Text] Based on the fundamental [illegible] the six-port circuit, the self-calibration equations derived from the [illegible] are presented. Several self-calibration methods are [illegible] the optimum method. The resulting set of computer [illegible] measurement on a six-port reflectometer shows that [illegible] in math error cancellation and self-calibration [illegible].
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A CAD ANALYTICAL METHOD AND CORRESPONDING PROGRAM FOR MICROWAVE FET NONLINEAR CIRCUITS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 13-19

[English abstract of article by Li Zhengfan [2621 1767 1581] of Shanghai Jiaotong University]

[Text] A CAD analytical method and its corresponding program for microwave FET nonlinear circuits are described. The contents include the nonlinear modeling of MESFET's, a quick convergence method for obtaining the steady state response of nonlinear state equations and a computing program. The CAD method and program can be delivered to resolve various microwave FET nonlinear circuits--multiplier, mixer, large signal amplifier, generator, etc. The results of the FET mixer using this method are given here as an example. (Paper received in June 1984; finalized in September 1984.)

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A MONOLITHIC INTEGRATED PIEZORESISTIVE PRESSURE TRANSDUCER

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 39-44

[English abstract of article by Wu Xianpin [0702 2009 1627] and Bao Minhang [7637 2404 2635] of Fudan University, Shanghai]

[Text] An integrated circuit pressure transducer consisting of a full bridge of piezoresistors with a novel design and an amplifier with temperature compensation is described. The configuration and dimensions of the (100) rectangular Si diaphragm as well as the locations and dimensions of the resistors are optimized through careful computation. The temperature coefficient of the whole circuit is analyzed and minimized. The design has been implemented by conventional bipolar IC technology and anisotropic chemical etching. The transducers fabricated show a sensitivity of about 1000 V/mmHg and have been used for physiological pressure measurement in clinical applications. (Paper received in September 1983; finalized in June 1984.)

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A METHOD FOR IDENTIFYING GYROTRON OUTPUT MODE COMPOSITIONS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 45-50

[English abstract of article by Zhang Zexiang [1728 3419 3276] of the Institute of Physics, Chinese Academy of Sciences, Beijing]

[Text] The identification of mode compositions of gyrotron output power is discussed using far-field radiation pattern analysis. A general analytical method and a simple experimental approach are given. The suggested method can also be used for measuring high power mode-conversion oversized waveguides. (Paper received in March 1984; finalized in June 1984.)

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ON CURVED ELECTRON BEAMS IN CROSSED ELECTRIC AND MAGNETIC FIELDS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 51-58

[English abstract of article by Ni Zhijun [0242 3112 6874] of Chengdu Institute of Radio Engineering]

[Text] According to the synthesis of the formation of electron beams, general solutions for space-charge flow and electrode shape are derived in a crossed electric and magnetic field electrode system in which the cathode operates under arbitrary conditions. Characteristics of some magnetron injection guns and crossed-field guns, based on the general solutions, are calculated and analyzed. The effects of the cathode surface electrid field intensity and electron initial velocity on electron trajectories and electrode shapes are discussed. (Paper received in January 1984; finalized in October 1984.)

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ON DYADIC GREEN'S FUNCTIONS IN SPHERICAL COORDINATES IN FREE SPACE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 13 No 5, Sep 85 pp 83-91

[English abstract of article by Pan Shenggen [3382 3932 2704] of Shanghai University of Science and Technology]

[Text] The dyadic Green's functions in spherical coordinates in free space are derived by the methods of $\overline{G}_A$, $\overline{G}_m$ and $\overline{G}_e^0$, and a systematic investigation is made of the general properties of the dyadic Green's functions at the source region. Ambiguities associated with dyadic operation in the literature are clarified and some errors are redressed.

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Nuclear Power Engineering

STRESS-CORROSION BEHAVIOR IN WATER MEDIA CONTAINING CHLORINE OF THE BRAZING JOINT OF GRIDS FOR PRESSURIZED WATER REACTOR FUEL ELEMENT

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 14-17

[English abstract of article by Zhang Weijie [1728 4850 2638] and Li Wenqing [2621 2429 3237]]

[Text] This paper details the testing results of the stress-corrosion behavior in 150°C water media containing chlorine for the brazing joints made from three alloy systems, Ni-Cr-Si, Ni-Cr-P and Ni-P, including 16 compositions. The test results indicate that, in the Ni-Cr-Si system, the Ni-Cr-Si-Ge brazing joint is the best for resisting stress-corrosion, while Ni-Cr-Si-P-Ge, Ni-Cr-Si-P-Ge-Pd and BNi5 brazing joints are fairly good. In the Ni-Cr-P system, only the Ni-Cr-P-Mo-Zr brazing joint has good resistance to stress-corrosion.

BERYLLIUM USED IN HFETR

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 18-24

[English abstract of article by Shi Jingxian [2168 2529 6343] and Xu Jiangqing [1776 3068 3237]]

[Text] This paper presents the design characteristics of the beryllium assembly used in a High Flux Engineering Test Reactor (HFETR) and gives some results of physical calculations for some physical problems of the reactor core which contains beryllium, e.g., the poison build-up in the beryllium reflector, etc.

MEASUREMENT OF SOURCE TRANSFER FUNCTION AND SPACE DEPENDENCE USING PULSED NEUTRON SOURCE ON BERYLLIUM-LIGHT WATER LATTICE

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 25-31

[English abstract of article by Peng Feng [1756 7685], Xie Jingwen [6200 2529 2429] and Wu Baoan [0702 1405 1344]]

[Text] This paper describes an on-line pulsed neutron source experiment on beryllium-light water lattice. Pulsed neutron source transfer functions are given. A space-dependent prompt neutron decay constant α has been found are results are discussed.

APPROACH OF DECONTAMINATION PERFORMANCE FOR THE EVAPORATING SYSTEM IN THE RADIOACTIVE WASTE TREATMENT FACILITIES OF HIGH FLUX ENGINEERING TEST REACTOR

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 32-37

[English abstract of article by Hu Zhenqian [5170 2182 0051]]

[Text] This report presents the removal of radioactive components from radioactive liquid waste by an evaporator, a cyclone and a demister and, in addition, describes the interrelationships of radioactive decontamination with mass velocity and the concentrating factor. Based on data obtained by the site equipment, the interrelationships are summarized as simple mathematical formulae. The paper also indicates that the demineralization characteristic can be applied to explain radioactive decontamination performance for an evaporator.

THE FLUX-LIMITED ASYMPTOTIC DIFFUSION THEORY

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 51-58

[English abstract of article by Liu Chengan [0491 2052 1344]]

[Text] In order to eliminate the classical diffusion theory's limitations on describing transport problems, the multigroup asymptotic diffusion equation and appropriate flux-limited methods have been derived from a special form of the angular distribution flux. For the scattering medium, the flux-limited asymptotic diffusion theory is in semiquantitative agreement with the various typical flux-limited diffusion theories. For the absorbing medium and multiplying medium, precision is presented by the asymptotic diffusion theory. It retains the simplicity and convenience of the classicial diffusion theory, but improves the precision in describing transport problems.

TRANSPORT EFFECT FOR CONTROL ROD CALCULATION

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 59-69, 76

[English abstract of article by Ma Dayuan [7456 1129 0954] and A. D'angelo]

[Text] Transport mesh-effect and transport effect for control rod calculation have been studied. The numerical results show that the mesh-size effect of transport calculation is small (approximately 30 percent or less of the corresponding diffusion calculation) and is of the opposite sign for mesh-centered flux diffusion calculations. The results also show that the axial transport effect, which has been neglected before, does exist, although it is very small and has the opposite sign of the horizontal transport effect. This means the control rod value is underestimated in the vertical direction by diffusion theory. In this paper, a simple method for treating the axial transport effect is discussed. The numerical results using this method are very close to the results of the reference method. The method presented in this paper is useful for getting an approximate result for a three-dimensional transport calculation.

AN ACCURATE TREATMENT OF ELASTIC SCATTERING IN LIGHT AND MEDIUM ELEMENTS IN FAST REACTORS

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 70-76

[English abstract of article by Li Zehua [2621 3419 5478] and Zhou Zhennian [0719 2182 1628]]

[Text] In this paper the newer data have been used for making multigroup accurate treatment of elastic scattering in light and medium elements in fast reactors in which the resonance treatment is more careful. A total of 491 resonance peaks, including Na, Fe, Cr and Ni elements, is calculated, and the contribution from the P wave is also considered.

Through the calculation the neutron spectrum is given for the normal fast experiment reactor core and a mock-up core with 50 percent of the normal Na density. This will be useful for fast reactor safety analysis.

DETERMINATION OF PLUTONIUM IN $Pu(SO_4)_2 \cdot 4H_2O$ BY CONTROLLED-POTENTIAL COULOMETRY

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 77-79, 86

[English abstract of article by Sun Wenhao [1327 2429 6275]]

[Text] In this paper a method for the determination of the plutonium in $Pu(SO_4)_2 \cdot 4H_2O$ by Controlled-Potential Coulometry is presented. The precision for determining about 3 mg is better than 0.1 percent. The results obtained by this method are compared with others, and it is proved to be precise and accurate.

PERFORMANCE MEASUREMENT OF ^{60}Co TELETHERAPY SOURCE IN EQUIPMENT AT USERS

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 6 No 5, Oct 85 pp 80-86

[English abstract of article by Li Xingyuan [2621 2502 0997], Chen Zigen [7115 1311 2704], et al.]

[Text] The main circular performance of a high activity ^{60}Co teletherapy source made in China for the first time is measured by a few methods after having been fitted in equipment at the users' sites. The results obtained provide useful parameters for production and application of the ^{60}Co teletherapy source.

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CRYSTAL STRUCTURE AND ELECTRONIC STRUCTURE OF cis-BIS(CHLOROACETATO)-2,3-DIMETHYL-2,3-BUTANEDIAMINOPLATINUM

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 6, Jun 85 pp 507-513

[English abstract of article by Qu Yun [2575 4596] and Tang Wenxia [0681 7186 7209], et al., of the Institute of Coordination Chemistry, Nanjing University; and Wang Fengshan [3769 7364 1472], et al., of the Department of Chemistry, Jilin University, Changchun]

[Text] The title compound was crystallized in space group $P2_12_12_1$ with unit cell constants, a = 9.866(4)Å, b = 16.356(2)Å, c = 19.501(4)Å, $\alpha = \beta = \gamma$ = 90°, and Z = 8. The intensities were collected with a Nicolet-R3 four-circle diffractometer. The Pt atom coordinates were derived from Patterson's function. The parameters of the other atoms were found from successive Fourier and difference Fourier syntheses. The block-diagonal least squares refinement for all atoms gave a final discrepancy factor R = 0.061. The results obtained showed that the title compound was a square planar complex with a diamine chelate ring conformation, and that the bond angle of O-Pt-O is equal to about 80°, much smaller than the corresponding value in other Pt complexes.

The electronic structure of the title compound was calculated by the CNDO/2 method. The unusual bond angle of O-Py-O and the relationship between the structure and antitumor function are discussed. (Paper received 23 December 1983, and finalized 12 November 1984.)

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STUDIES OF o-HYDROXYBENZYLAMINE-N, N, O-TRIACETIC ACID (HBATA) AND ITS COMPLEXES. II. CHELATES OF YTTRIUM AND YTTERBIUM

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 6, Jun 85 pp 562-565

[English abstract of article by Zhang Hualin [1728 5478 7792] and Xu Kangcheng [1776 2123 2052] of the Department of Chemistry, Fudan University, Shanghai]

[Text] The stability constants of HBATA with Y(III) and Yb(III) were determined pH-metrically in aqueous solution at 30.0 ± 0.1°C in the presence of 0.1M potassium nitrate, with log k_1 being 9.55 for Y(III) and 10.73 for Yb(III). $ML \cdot 3H_2O$ (M = Y or Yb, L = HBATA) was prepared and characterized by elemental analyses, molar conductance, magnetic moment and infrared spectra studies. The thermal decomposition of the Y(III) chelate was studied by TG, DTG and DTA techniques. The results indicate that the ether-bonded oxygen atom in HBATA is coordinated to the metal in these chelates, therefore HBATA acts as a quinqhedentate ligand and the coordination number of Y(III) may possibly be eight. (Paper received 24 April 1984.)

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Physical Chemistry

THERMODYNAMICS OF MULTICOMPONENT ELECTROLYTE SOLUTIONS. II. ACTIVITY COEFFICIENT FOR THE SYSTEM HCl-$CoCl_2$-H_2O AT 298.15K

Shanghai HUAXUE XUEBAO [ACTA CHIMICA SINICA] in Chinese Vol 43 No 6, Jun 85 pp 557-561

[English abstract of article by Chu Mingchen [0443 2494 2525], Liang Chunyu [2733 2504 0151] and Yang Jiazhen [2799 1367 2182] of the Department of Chemistry, Liaoning University, Shenyang]

[Text] Activity coefficients for HCl in the system HCl-$CoCl_2$-H_2O at 298.15K and at constant total ionic strengths of 0.1, 0.5, 1.0, 2.0, 3.0, 4.0 and 5.0 mol·kg^{-1} have been measured by the EMF method. The results have been treated using Harned's and Pitzer's equations for mixed electrolyte solutions. The results show that HCl follows Harned's Rule at constant total ionic strength from 0.1 to 5.0 mol·kg^{-1} at 298.15K. The mixing parameters θ and ψ have been obtained by using three methods and activity coefficients for the salt $CoCl_2$ have been derived. The results obtained by the three methods are in agreement within experimental error. (Paper received 27 March 1984.)

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